

ZIPSTOP ZIP LINE BRAKE



Installation Manual

Models: ZS125-08 / ZSIR150-20A / ZSSD150-20A



NOTE TO INSTALLERS

Always Read Instructions Before Use

The Installation manual contains information relating to the proper installation, configuration and testing of the zipSTOP Zip Line Brakes and includes all product registration and warranty information. This document must be supplied to the owner after installation. Ensure that this manual is readily available to the responsible parties at all times.

Head Rush Technologies Manual - zipSTOP Installation Manual
P/N 11911-04

Head Rush Technologies products are covered by a number of patents, including
U.S. Patents 8,490,751; 8,851,235; 9,016,435 and D654,412 & corresponding patents/applications in the USA and in other countries worldwide.



zip STOP™

ZIP LINE BRAKE

SPEED



CAUTION

Read and adhere to all product labels (front & reverse of device) and Operator Instructions. Inspect device before each use. Failure to adhere to these instructions may result in serious or fatal injury.

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U.S. Patents 6,490,751; 6,951,235; 9,016,435 and D654,428 corresponding patents/applications in the U.S. and in other countries worldwide.

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SAFETY INFORMATION

Safety Warnings

READ BEFORE INSTALLATION & OPERATION

WARNING



DO NOT USE OR INSTALL A ZIPSTOP UNLESS AN EMERGENCY ARREST DEVICE (EAD) THAT PREVENTS SERIOUS INJURY* OR DEATH, MAKES THE BRAKING SYSTEM FAIL-SAFE, AND MEETS THE REQUIREMENTS SPECIFIED IN THIS MANUAL IS PRESENT

All Requirements and Instructions Must be Followed to Achieve Proper Operation and Participant Safety

DO NOT USE A ZIPSTOP UNLESS ALL INSTRUCTIONS AND REQUIREMENTS ARE SATISFIED

Prior to installation and operation, all Responsible Parties must have read and shown to have understood all requirements, instructions, labels, markings and safety information pertaining to the correct installation, operations, inspection and maintenance of the zipSTOP brake, its component parts and all associated hardware and systems. Failure to do so may result in equipment damage, serious injury or death.

*Serious injury includes any of the following injuries: fractures, amputations / dismemberment, permanent loss of the use of a body organ / member / function / system, injury likely to lead to permanent loss or reduction of sight, any crush injury to the head or torso causing damage to the brain or internal organs, serious burns, any scalping, any loss of consciousness caused by head injury or asphyxia, significant disfigurement, loss of a fetus, or other significant injury / illness that requires immediate admission and overnight hospitalization and observation by a licensed health care professional.

Serious injury is also commonly determined by the Authority Having Jurisdiction, the more conservative definition applies.

Definition from EN15567 and ASTM F2959

WARNING



The following items are critical and must be understood by all persons involved with the installation, operation, and service of a zip line utilizing a zipSTOP. This includes, but is not limited to: all Responsible Parties, guides / operators, owners, service technicians, designers, installers, etc.

- **Emergency Arrest Device** – a suitable Emergency Arrest Device (EAD) that meets the requirements specified in this manual must be used at all times.
- **Arrival Speed** – the device / configuration arrival speed limits must NEVER be exceeded in any condition.
- **Qualified Person(s)** - The installation and commissioning of a zipSTOP equipped braking system must be completed by a qualified person(s). Head Rush Technologies is not a zip line brake system designer or installer and therefore cannot approve zip line braking systems.
- **Minimum Requirements** – All minimum requirements in this manual must be satisfied
 - Redirection Rope – redirection systems require the use of Gorilla Rope or direct equivalent.
 - Compatible Components – all components used must be compatible with the system, including: redirection pulley, brake trolley, rider trolley, etc.
- **Inspection** – Prior to every descent, the redirection system and EAD must be inspected for readiness including proper reset and entanglement hazards.
- **Correct Installation and Operation** – This manual illustrates only some of the possible correct and incorrect methods of installation and operation. It is impossible to address every scenario and configuration relating to the use of this equipment. It is ultimately up to the qualified person(s) and Responsible Party to ensure safe and correct installation and operation.
- **Risk Assessment and Rescue** – A risk assessment including a ride and failure analysis must be conducted and corresponding rescue plan in place prior to the installation and use of the zipSTOP.

Symbols Used in this Manual

The following safety symbols are used throughout this manual to highlight potential danger to participants and equipment. One or more precautions may be associated with practices and procedures described within this manual. Failure to adhere to any precautions highlighted can result in equipment damage, serious injury or death.



Indicates a *potentially hazardous situation* exists that, if warnings are not observed, may result in improper operation, equipment damage, serious injury or death.



Indicates an *action that must be taken* to prevent improper operations, equipment damage, serious injury or death.



Indicates a scenario, configuration, action, etc. that is *not allowed* and may result in improper operation, equipment damage, serious injury or death.

Safety Information

The zipSTOP Brake assembly, including zipSTOP Brake Units Models zipSTOP ZS125-08, zipSTOP IR ZSIR150-20A and zipSTOP SPEED ZSSD150-20A, zipSTOP Brake Trolley ZT125-17 and all accessories are designed and specified for use in the recreational zip line industry as components within a braking system designed by a qualified person. Use of the zipSTOP device or accessories for any purposes other than that intended by the manufacturer is not permitted.

The zipSTOP is designed to be utilized as a Primary Brake or Emergency Arrest Device (EAD). When using the zipSTOP as a primary brake, the Responsible Parties MUST utilize an independent EAD to protect against operator error and equipment failure. When used as an EAD, the zipSTOP configuration must meet all Head Rush Technologies' and other applicable requirements. Design, installation, and qualification of the zip line ride, including the braking system, must be completed by a qualified person and is the responsibility of the installer, owner, engineer, designer or other Responsible Party.

Owners and Operators of zipSTOP devices are responsible for the safety and supervision of any person using the zip line and are required to undergo training in the correct operation, inspection and maintenance prior to any use. Designers, Installers and/or other Responsible Parties must assure that proper installation and operational training are documented and provided to the Owner / Operator. Proper installation requires careful design and planning using zipSTOP and non-zipSTOP components. Proper operational procedure is left up to the Responsible Party and must ensure compatibility with all hardware, systems, other ride requirements and procedures.

Responsible Parties are encouraged to seek the advice of a zip line installer, designer/engineer, or other qualified person regarding the instructions in this Manual. Head Rush Technologies is not a designer or installer and therefore cannot approve a zip line braking system.



THESE INSTRUCTIONS MUST BE MADE READILY AVAILABLE TO ALL RESPONSIBLE PARTIES AT ALL TIMES.

Emergency Arrest Device (EAD) Confirmation



THE EAD MUST PREVENT SERIOUS INJURY OR DEATH AND BE FAIL-SAFE. ZIP LINES USING THE ZIPSTOP BRAKE ARE REQUIRED TO USE INDEPENDENT PRIMARY AND EMERGENCY ARREST DEVICES TO ARREST THE MOTION OF RIDERS.

Use of an EAD that prevents serious injury and makes the braking system fail-safe is required. The EAD must automatically engage upon failure of the primary brake. An EAD cannot be dependent on a participant or guide to engage upon failure of the primary brake and cannot be tethered to or use the reset of the zipSTOP to reset the EAD.

Installation and use of a zipSTOP constitutes acknowledgement by the Responsible Party that the following requirements regarding use of an adequate EAD have been satisfied:

- The Installation and Operation and Maintenance Manuals have been understood by all Responsible Parties.
- An adequate EAD rated to the arrival speed and weight range which makes the braking system fail-safe is present, functional and inspected prior to every zip line descent.
- The EAD has been tested by a qualified person in accordance with this manual, ASTM F2959 and other requirements in accordance with the Authority Having Jurisdiction and has been shown to make the braking system fail-safe independent of the primary brake for all rider weights, speeds and orientations.

Regulations and Standards

The zipSTOP, zipSTOP IR and zipSTOP SPEED devices and supplied components comply with all applicable requirements of ASTM F2959-18 Standard Practice for Aerial Adventure Courses.

All zipSTOP Devices, Brake Trolley, and all Head Rush Technologies' accessories are designed for use as components within a zip line braking system. A zipSTOP device may be operated so long as a qualified person designs and installs a suitable braking system that meets or exceeds all requirements stated in this manual and any applicable requirements in accordance with the Authority Having Jurisdiction. Applicable standards may include, but are not limited to, Association for Challenge Course Technology (ACCT), EN 15567-1 Sports and Recreational Facilities – Ropes Courses, Professional Ropes Course Association (PRCA), ASTM F2959 Standard Practice for Aerial Adventure Courses, and ASTM F770 Standard Practice for Ownership and Operation of Amusement Rides and Devices.

Warranty

Manufacturers sole warranty. The zipSTOP Brake assembly will be sold free from defects in materials and workmanship, excluding field replaceable wear parts, for a period of one (1) year from date of purchase. This warranty only applies to the original purchaser, and is contingent upon the Responsible Parties using and maintaining the device in accordance with the zipSTOP instructions, including the requirement to maintain annual recertification as described in the Installation and Operation and Maintenance Manuals.

This warranty is expressly in lieu of other warranties, express or implied, and any implied warranty of merchantability or fitness for a particular purpose is hereby expressly excluded. The sole remedy for breach of said warranty or for any claim in negligence or strict liability in tort is the repair or replacement of any defective parts at the discretion of the manufacturer. Such parts claimed to be defective shall be returned to the Head Rush Technologies Service Center, transportation prepaid, for inspection by an authorized Head Rush service technician to determine to its satisfaction that said part(s) are defective.

This warranty is null and void if other than genuine parts are used, if any modifications are carried out to the zipSTOP Brake assembly or zipSTOP components without the expressed written permission of the manufacturer, such as if used outside of intended application or beyond the stated device weight and speed limits.

No person, Agent or Distributor is authorized to give any warranty, other than the one herein expressed, on behalf of the Company or to assume for it any liability pertaining to such products. The company makes no warranties in respect to trade accessories or component parts which are not manufactured by the company, same being subject only to such warranties, if any, as may be made by their respective manufacturers.

INTRODUCTION

How the zipSTOP Zip Line Brake Works

The zipSTOP Zip Line Brake is a patented self-regulating eddy current braking device designed to be used as a component within the braking system at the terminal end of a zip line. The zipSTOP has a self-regulating brake design and can accommodate a range of rider weights and arrival speeds without external input. The zipSTOP is connected to a brake trolley at the terminal end of the zip line; when the arriving rider contacts the brake trolley the webbing is pulled out from the zipSTOP which transmits braking force to the rider. The extension of the webbing spins a conductive rotor within a counter-rotating magnetic field. The relative motion between the rotor and magnetic field creates a magnetic drag force, called eddy current braking (ECB), due to electromagnetic induction, providing a braking force to the webbing and brake trolley gently stopping the rider. After the rider dismounts, a spring within the zipSTOP automatically retracts the webbing and resets the brake trolley so it is ready for the next rider.

Every zip line is different and every braking system must be designed to satisfy specific requirements. Three different zipSTOP models are available which may be configured in different ways to accommodate a range of arrival speeds, weights and site specific conditions. The Responsible Parties must ensure the finalized braking system is satisfactory for the allowable operational range, meets the needs of the system and applicable standards. Unmanned testing and qualification is required with all installations. The purpose of this manual is to provide guidance on suggested practices and configurations; it is not intended to address every possible configuration or scenario. It is ultimately up to the Responsible Parties to ensure the complete braking system is adequate and compatible with the requirements and needs of the zip line.

Additional information regarding the installation and use of zipSTOPs, EADs, accessories, inspection, maintenance and many other topics may be found at www.headrushtech.com.



THE FIGURES PRESENTED IN THIS MANUAL ARE NOT TO SCALE AND MAY NOT SHOW ALL REQUIRED COMPONENTS OR STRUCTURES, INCLUDING, BUT NOT LIMITED TO: EAD, ANCHORS, GUY LINES, SAFETY EQUIPMENT, ETC.



IT IS UP TO THE RESPONSIBLE PARTY TO ENSURE THAT THE BRAKING SYSTEM INCLUDES ALL NECESSARY EQUIPMENT, IS APPROPRIATELY DESIGNED AND FUNCTIONAL FOR THE LIFE OF THE ZIPLINE. THIS MAY INCLUDE PERIODIC INSPECTION, MAINTENANCE AND REPLACEMENT OF COMPONENTS.

Models, Specifications, and Parts: zipSTOP and Brake Trolley

Three models of zipSTOP are available to accommodate a range of arrival speeds. Every zipSTOP comes with a brake trolley and mounting bracket for anchoring the zipSTOP. The owner should keep the original packaging to use for storage and shipping of the device.

All zipSTOP Models

OPERATING TEMPERATURE	-4°C (25°F) to 60°C (140°F)
OPERATING TEMPERATURE DRY	-10°C (14°F) to 60°C (140°F)
STORAGE TEMPERATURE	-20°C (-4°F) to 60°C (140°F)
WEIGHT RANGE	15 to 150 kg (33 – 330 lbs)

zipSTOP Brake Unit, ZS125-08

MAXIMUM WEBBING EXTENSION	12.5 m (41 ft)	
MAXIMUM ARRIVAL SPEED	1:1 REDIRECTION RATIO	36 km/h (22 mph)
	2:1 REDIRECTION RATIO	60 km/h (37 mph)

zipSTOP IR Brake Unit, ZSIR150-20A

MAXIMUM WEBBING EXTENSION	20 m (65 ft)	
MAXIMUM ARRIVAL SPEED*	1:1 REDIRECTION RATIO	60 km/h (37 mph)

* Only 1:1 Redirection Ratio Allowed

zipSTOP SPEED Brake Unit, ZSSD150-20A

MAXIMUM WEBBING EXTENSION	20 m (65 ft)	
MAXIMUM ARRIVAL SPEED**	2:1 REDIRECTION RATIO	72 km/h (45 mph)

** Only 2:1 Reduction Ratio Allowed

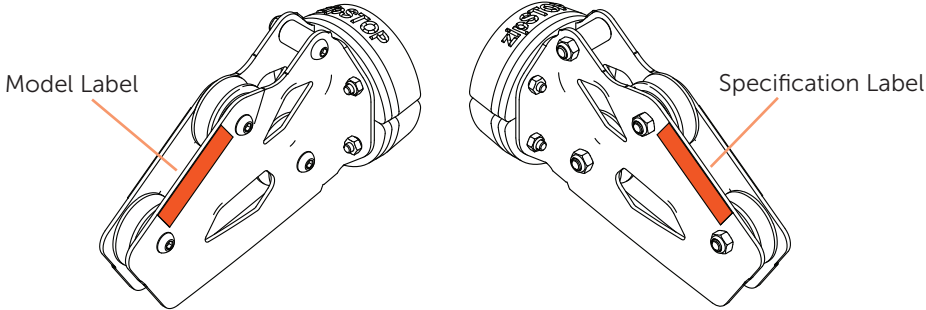
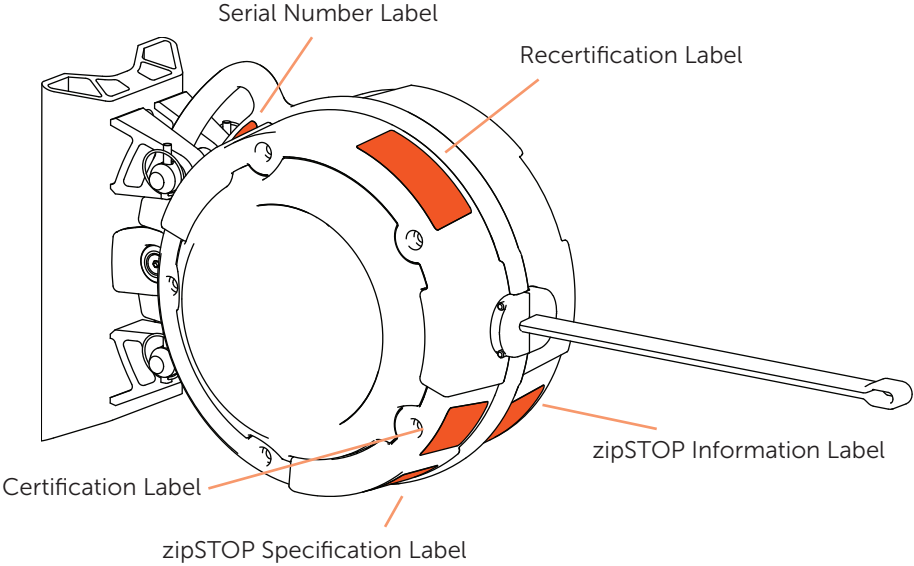
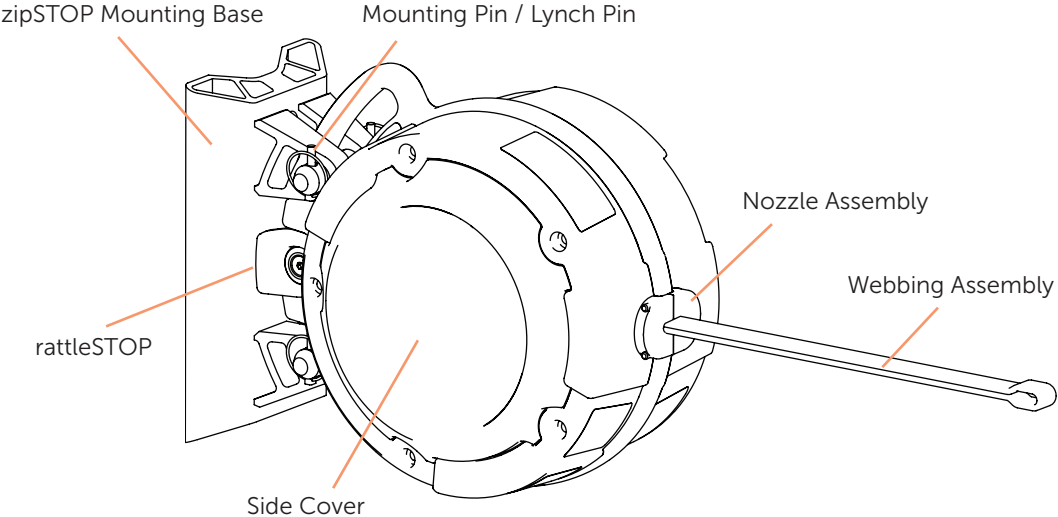
NOTE: All Reduction Ratios must be configured properly for reliable, automatic reset. Operating without reliable, automatic reset is not allowed.

NOTE: Maximum webbing extension is not the braking distance, but refers to the amount of webbing in the device. Refer to the braking distance charts to see Braking Line Extension.

zipSTOP Brake Trolley

ZT 125-17-1/2	For use with ½ inch [12-13mm] zip lines
ZT 125-17-5/8	For use with ⅝ inch [16mm] zip lines
ZT 125-17-3/4	For use with ¾ inch [19mm] zip lines

The following nomenclature and components are referenced throughout the Installation and Operation and Maintenance Manuals.



REDIRECTION AND REDUCTION SYSTEMS

The zipSTOP Zip Line Brake is a component within a zip line braking system. With the exception of installation using a Pivot Mount (see Pivot Mount Manual), all zipSTOPs require a redirection system to connect the brake trolley to the zipSTOP webbing. A 2:1 reduction system is possible in a zipSTOP and required in a zipSTOP SPEED installation. A reduction system is a redirection system that utilizes pulleys to reduce the webbing speed and extension relative to the arrival speed and is only allowed in configurations specified in this manual. The following sections include diagrams and explanations to illustrate allowable configurations and how each configuration operates.



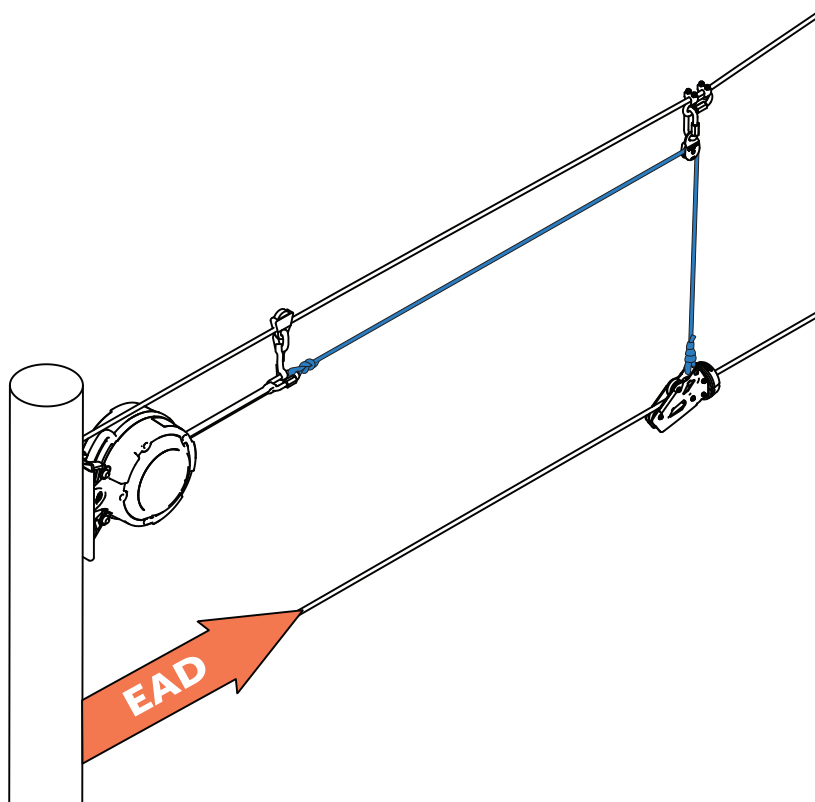
THE ONLY ACCEPTABLE DEVICE REDUCTION RATIOS ARE SPECIFIED BELOW AND INCLUDE A ZIPSTOP 1:1, ZIPSTOP 2:1, ZIPSTOP IR 1:1, ZIPSTOP SPEED 2:1.

USING A ZIPSTOP WITH A REDUCTION RATIO WHICH IS NOT EXPLICITLY SPECIFIED IS NOT ALLOWED. 3:1 AND HIGHER REDUCTIONS ARE PROHIBITED.

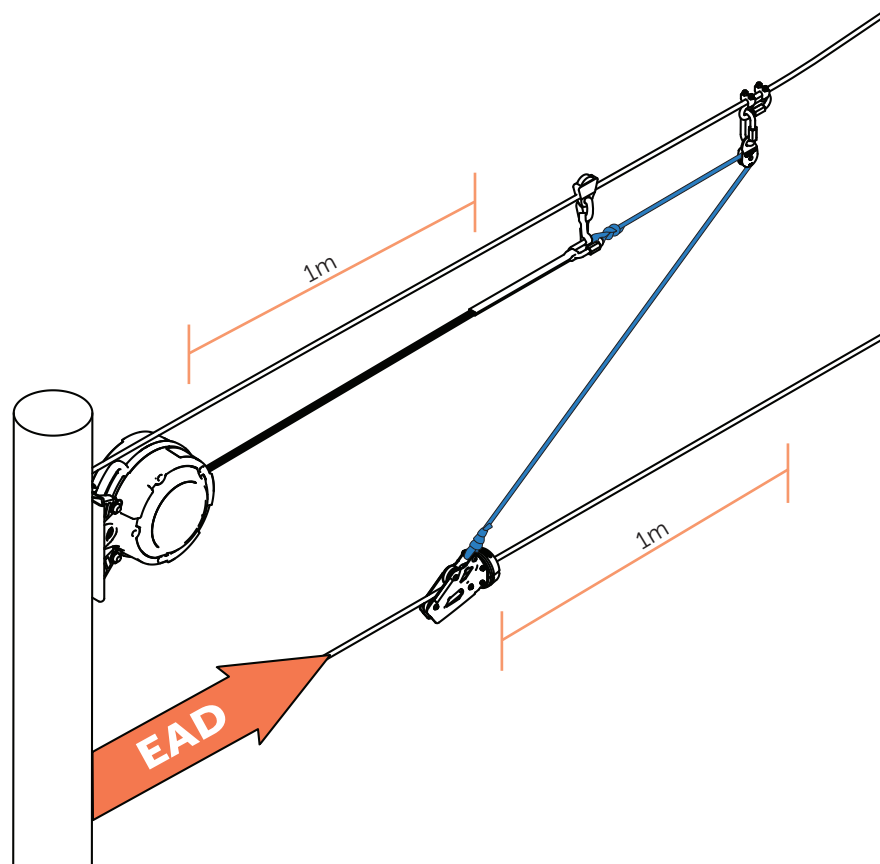
Redirection Systems

In a 1:1 ratio redirection system, the brake trolley is directly connected to zipSTOP webbing using the redirection rope. For every 1m the brake trolley moves, the zipSTOP webbing extends by 1m (not accounting for the effect of pivot height). The two figures below show this system in the reset position and during braking. Installations with 1:1 redirection systems increase simplicity, and aid inspectability.

A 1:1 ratio can accommodate arrival speeds up to 36 kph [22 mph] with a zipSTOP and 60 kph [37 mph] with a zipSTOP IR. A 1:1 ratio is the only approved configuration for the zipSTOP IR and performs comparably to a zipSTOP in a 2:1 configuration without the added complexity of a reduction system.



1:1 Ratio Redirection in the Reset Position



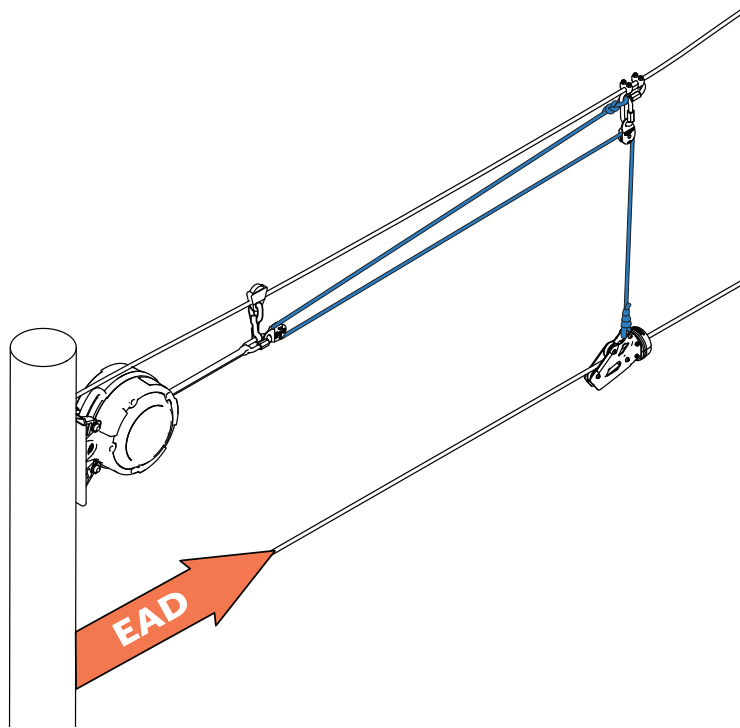
1:1 Ratio Redirection During Braking

2:1 Reduction Ratio

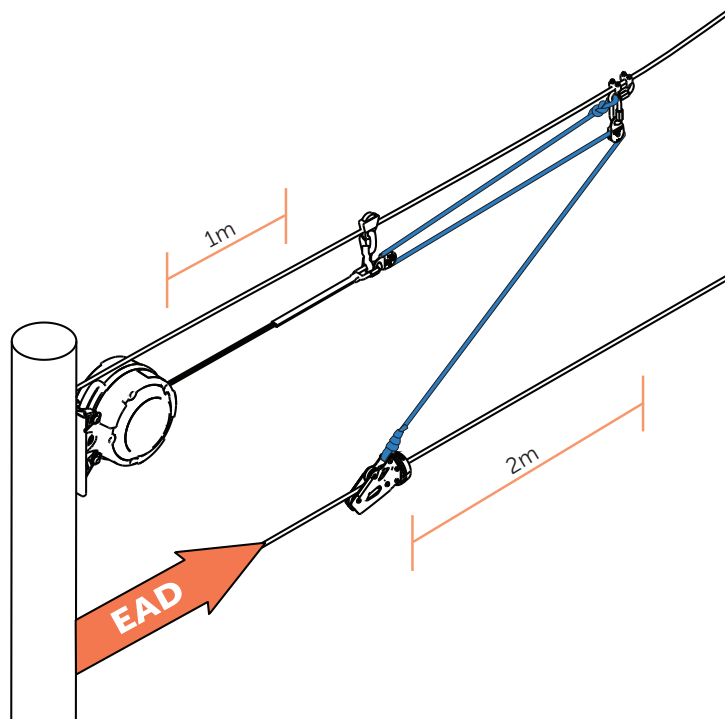
In a 2:1 Reduction Ratio system, the redirection rope connecting the brake trolley to the zipSTOP webbing is routed through a pulley at the end of the webbing to produce a 2:1 ratio. For every 2m the brake trolley moves, the zipSTOP webbing extends by 1m (not accounting for the effect of pivot height) and at half the speed of the brake trolley. The two figures below show this system in the reset position and during braking. Installations utilizing a 2:1 reduction system may be more complex, require additional inspection and testing.

A 2:1 ratio is designed for arrival speeds up to 60 kph [37 mph] with a zipSTOP and 72 kph [45 mph] with the zipSTOP SPEED. A 2:1 ratio is the only approved configuration for the zipSTOP SPEED.

When configuring a zipSTOP SPEED, the longer braking distance requires adequate support of the redirection rope using a traveler assembly and support pulleys. Refer to Section: **2:1 Reduction Configurations** for detailed configuration information.



2:1 Reduction Ratio in the Reset Position

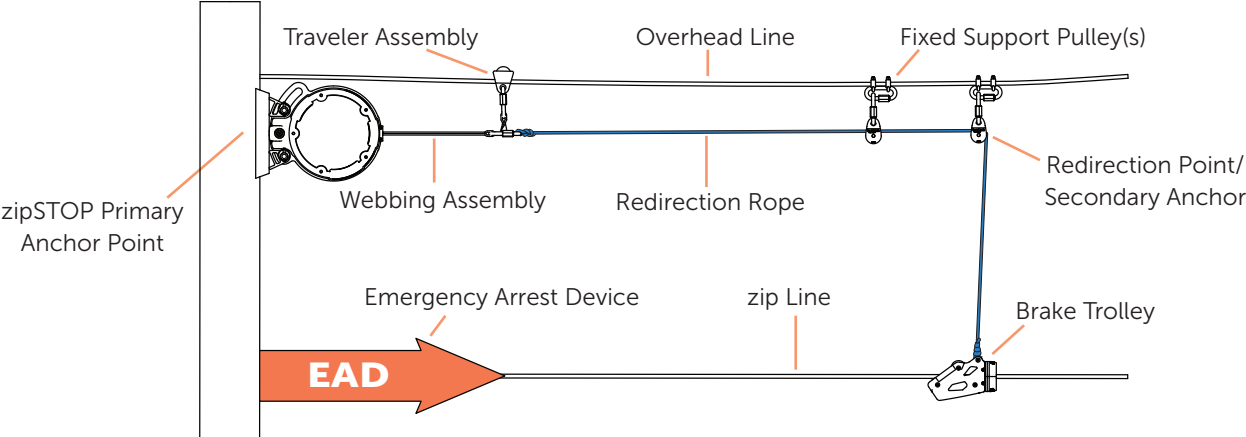


2:1 Reduction Ratio During Braking

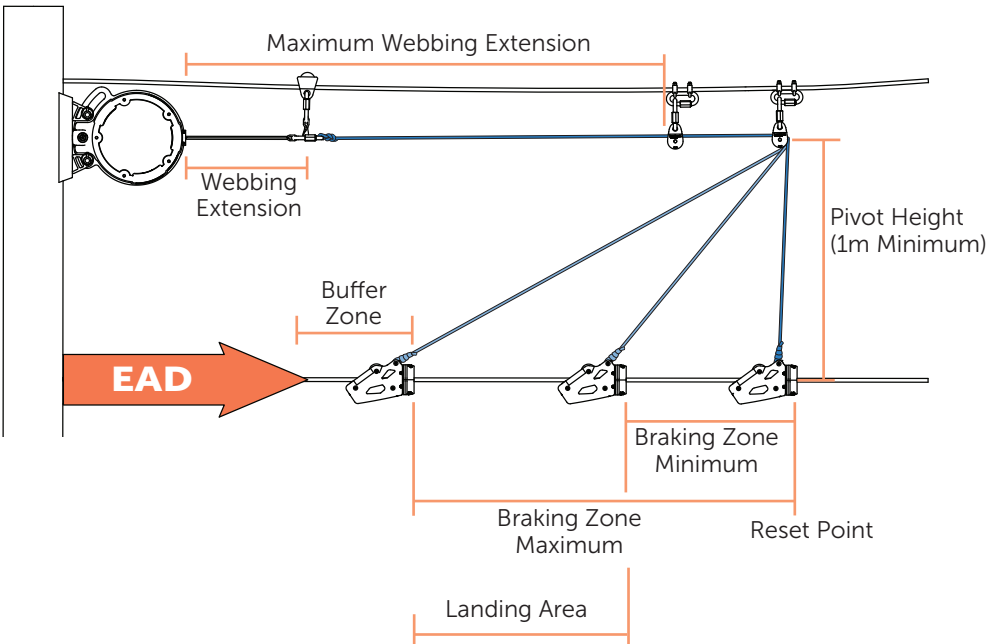
ZIPSTOP BRAKING SYSTEM COMPONENTS

Redirection/Reduction System Components

The below diagrams illustrate the typical components within a typical zipSTOP line braking system. Depending on the installation, additional or fewer components may be required.



Redirection System Components



Braking Zone Dimensions



THE FOLLOWING ITEMS AND WARNINGS APPLY TO ALL REDIRECTION SYSTEMS AND MUST BE ACCOUNTED FOR DURING THE DESIGN, INSTALLATION, TESTING AND OPERATION OF ANY BRAKING SYSTEM UTILIZING A ZIPSTOP.

WARNINGS

- Prior to every descent, the braking system must be inspected that it is ready for use.
- Braking and zip line configurations should facilitate inspection of all components / systems.
- Redirection ropes must run “free and clear” from contact or entanglement with other components. Damage to the rope or webbing may occur if it contacts another component while under motion/load.
- Redirection ropes can become twisted, entangled or rub on an overhead cable, the zip line cable, other structures or hardware and MUST be inspected along with complete brake system reset prior to every descent.
- Braking system must be designed such that reliable reset is achieved after every use.
- Rupture of the redirection rope or zipSTOP webbing will disconnect the rider from the zipSTOP resulting in no braking applied to the rider. Frequent inspection (at least daily) of all textiles is required.
- Failure of the zipSTOP to reset the brake trolley will result in no braking from the zipSTOP, inadequate braking capacity, abrupt braking, etc.

Emergency Arrest Device - EAD



THE EAD MUST PREVENT SERIOUS INJURY OR DEATH AND BE FAIL-SAFE. ZIP LINES USING THE ZIPSTOP BRAKE ARE REQUIRED TO USE INDEPENDENT PRIMARY AND EMERGENCY ARREST DEVICES TO ARREST THE MOTION OF RIDERS.

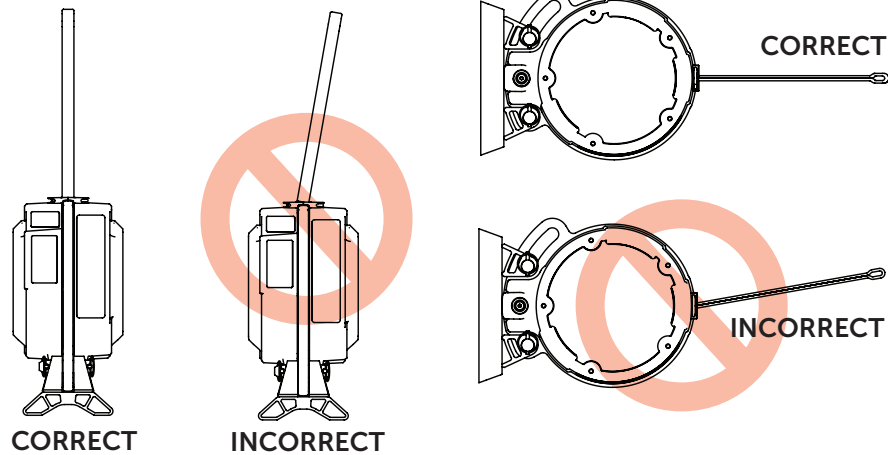
An EAD is a suitably designed, engineered and tested independent secondary brake that stops a rider in order to make the braking system fail-safe in the event the primary brake does not perform as designed. EADs are required by Head Rush Technologies whenever a zipSTOP is used as the primary brake. The EAD must automatically engage upon failure of the primary brake and be rated for the arrival speed and weight range. An EAD cannot be dependent on a participant or guide to engage upon failure of the primary brake and cannot be tethered to or use the reset of the zipSTOP to reset the EAD.

Primary Anchor Point

The Primary Anchor Point provides support for the zipSTOP Brake Unit. Every zipSTOP device is provided with a mounting base which can accommodate mounting on a flat or cylindrical anchor structure. The terminal structure is commonly used as the primary anchor point and as the anchor point for an overhead cable. The location and orientation of the primary anchor point shall be chosen to ensure the webbing is aligned with the redirection point and pulls straight out of the device. If using an overhead line, the primary anchor point must be positioned just below the line and as close as possible to it.



THE WEBBING MUST BE PROPERLY ALIGNED TO PREVENT ACCELERATED WEBBING WEAR.



Correct and Incorrect Webbing Alignment

The loads provided in the table below are the theoretical highest that would be expected at the Primary Anchor Point and are based on the operational limits of the device. Loads specified are for a single zipSTOP Brake assembly installation only and do not account for any additional equipment or other loads applied to the primary mount. These loads apply if using a Pivot Mount.



THE PRIMARY ANCHOR POINT MUST BE OF SUFFICIENT STRENGTH AND FORM TO WITHSTAND ALL APPLIED LOADS DURING THE BRAKING OPERATION.

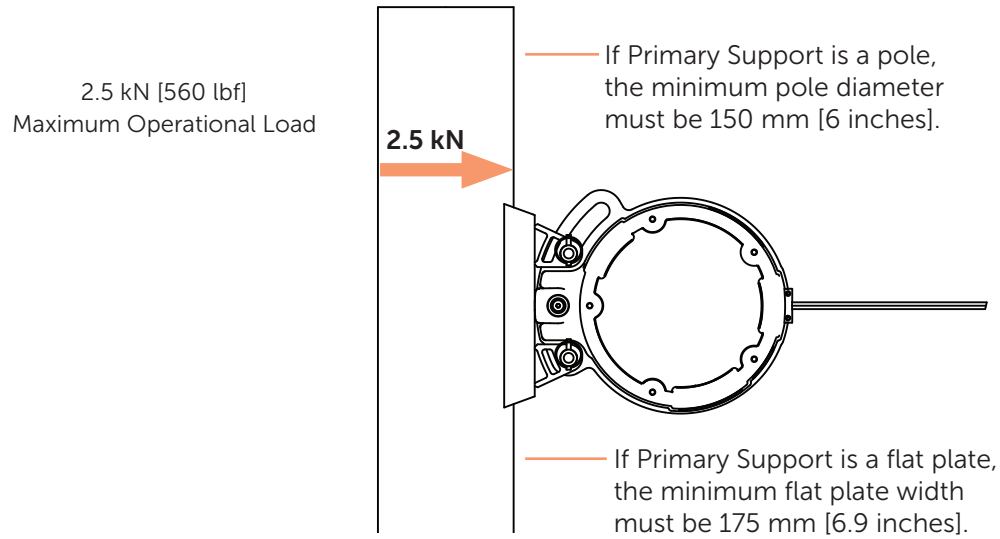
LOADS SPECIFIED DO NOT INCLUDE A FACTOR OF SAFETY, IT IS UP TO THE RESPONSIBLE PARTY TO ENSURE AN ADEQUATE FACTOR OF SAFETY ON THE ANCHORAGES OR STRUCTURES IS IMPLEMENTED AS REQUIRED BY APPLICABLE DESIGN REQUIREMENTS OR BY THE AUTHORITY HAVING JURISDICTION.

All zipSTOP Models: Max Operational Loads at Primary Anchor Point

IN-LINE WITH BRAKING LINE	2.5 kN
RIGHT ANGLES TO BRAKING LINE	NEGLIGIBLE

Max Operational Load at Primary Anchor Point

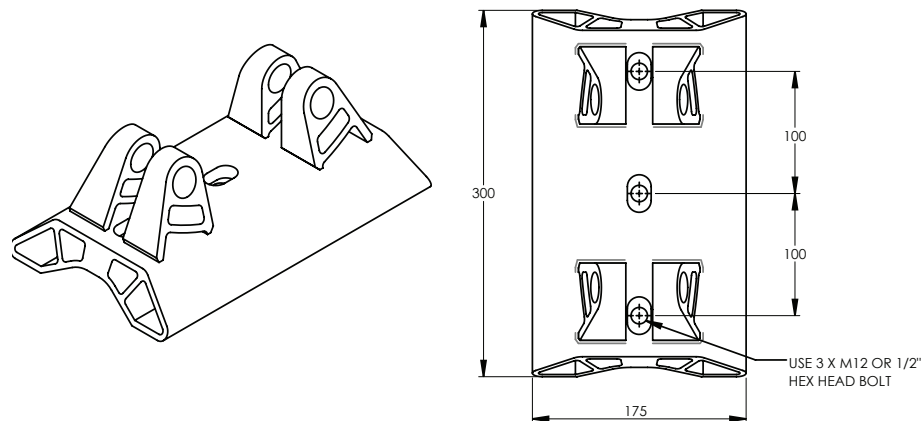
zipSTOP Base Mounting



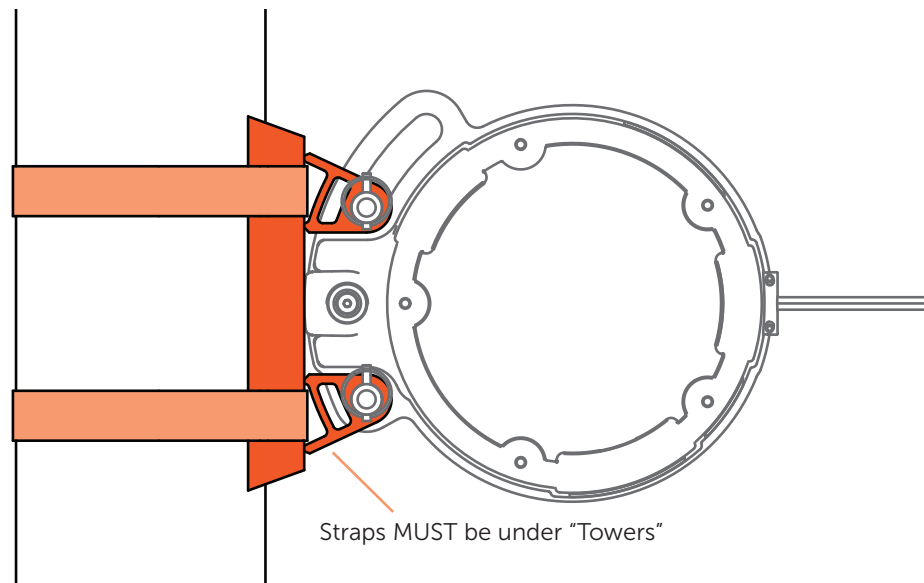
zipSTOP Primary Anchor Point

MOUNTING THE ZIPSTOP BASE

The zipSTOP Mounting Base is attached to the Primary Anchor Point using three M12 or 1/2 inch through bolts. Ratchet straps or other flexible / metallic banding is acceptable with the approval of the Responsible Party and in accordance with the strap / banding manufacturer's instructions. Straps must pass under the four (4) zipSTOP Mounting Base "towers" as shown below, avoid sharp edges, have a minimum pole diameter of 150mm cm [6inches], ensure no slip, use compatible components, and inspection frequency / criteria must be increased per the Responsible Party.



zipSTOP Mounting Base



Straped Mounted zipSTOP Base

Secondary Anchor Point and Overhead Cables

The secondary anchor point provides support for the redirection pulley and additional hardware used in the redirection system. It is located in line (and directly above if using an overhead cable) with the start of the Arrest Zone / Brake trolley reset point. The position of the secondary anchor point must ensure the 1m minimum pivot height can be achieved, refer to Section: **Pivot Height**.

An overhead cable is the most common method for setting up the secondary anchor point and facilitates moving the redirection point forward or backward. Overhead cables enable the use of a traveler assembly and fixed support pulleys to reduce redirection rope sag and may be required for smooth operation and with longer braking distances. The zip line designer should plan for the overhead cable to span at least the maximum braking distance to ensure arrival speeds higher than anticipated can be accommodated.

The secondary anchor point must be of sufficient strength and form to withstand all applied loads throughout the rider's descent and during the braking operation. The loads provided in the table below are the theoretical highest that would be expected at the Secondary Anchor Point and are based on the operational limits of the device during normal operation. If using an overhead cable, deflection and dynamic movement must be accounted for during design and testing. The values do not include a factor of safety and it is up to the Responsible Party to ensure an adequate factor of safety is implemented as required by applicable design requirements or local, federal, state, or other regulations. Loads specified are for a single zipSTOP Brake assembly installations only and do not account for any additional equipment or other loads applied to the secondary mount.

For additional secondary anchor point options, refer to Section: **Alternate Configurations: Pivot Mount, Offset Pole, Etc.**



THE SECONDARY ANCHOR POINT MUST BE OF SUFFICIENT STRENGTH AND FORM TO WITHSTAND ALL APPLIED LOADS DURING THE BRAKING OPERATION. LOADS SPECIFIED DO NOT INCLUDE A FACTOR OF SAFETY AND IT IS UP TO THE RESPONSIBLE PARTY TO ENSURE AN ADEQUATE FACTOR OF SAFETY IS IMPLEMENTED AS REQUIRED BY APPLICABLE DESIGN REQUIREMENTS OR BY THE AUTHORITY HAVING JURISDICTION.

zipSTOP 1:1 Ratio Max Operational Loads at Secondary Anchor Point

IN-LINE WITH BRAKING LINE	4.7 kN
RIGHT ANGLES TO BRAKING LINE	1.4 kN

zipSTOP 2:1 Ratio Max Operational Loads at Secondary Anchor Point

IN-LINE WITH BRAKING LINE	3.8 kN
RIGHT ANGLES TO BRAKING LINE	0.6 kN

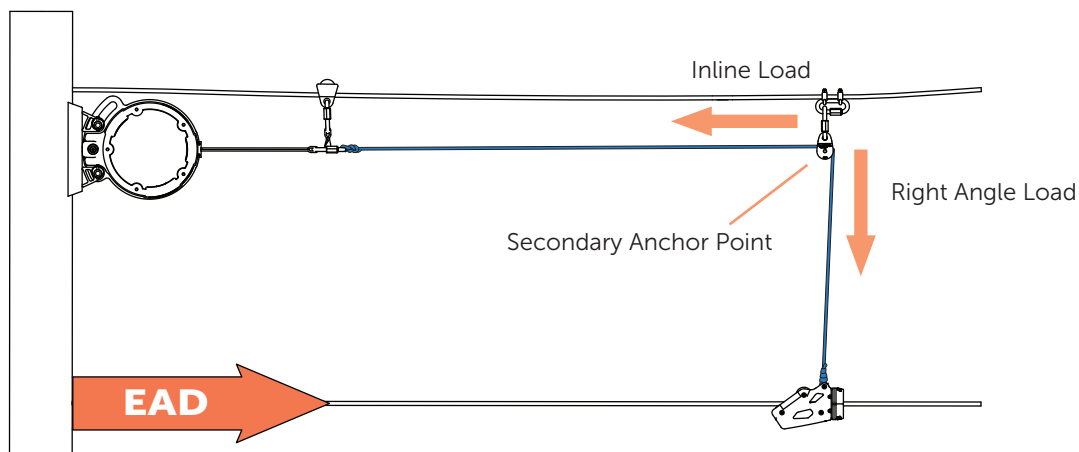
zipSTOP IR 1:1 Ratio Max Operational Loads at Secondary Anchor Point

IN-LINE WITH BRAKING LINE	3.8 kN
RIGHT ANGLES TO BRAKING LINE	0.6 kN

zipSTOP SPEED 2:1 Ratio Max Operational Loads at Secondary Anchor Point

IN-LINE WITH BRAKING LINE	3.2 kN
RIGHT ANGLES TO BRAKING LINE	0.4kN

Maximum Operational Loads at Secondary Anchor Point



Load Directions at Secondary Anchor Point

Brake Trolley

The zipSTOP brake trolley captures the zip line and is connected to the zipSTOP webbing via the redirection rope. Arriving riders contact the brake trolley and travel down the line with it, extending the zipSTOP webbing providing braking force to the rider. The brake trolley must be compatible with the zip line cable type, diameter and rider trolley. The zipSTOP brake trolley can accommodate cable diameters of 1/2 inch [12-13 mm], 5/8 inch [16mm] or 3/4 inch [19mm] and uses two bumpSTOPS, wearable rubber impact surfaces at the front of the brake trolley, for quiet, smooth operation and to minimize wear on rider trolleys. If a brake trolley other than the zipSTOP trolley is used, it is up to the Responsible Party to ensure compatibility. The brake trolley must have low rolling resistance.

Redirection Rope

The redirection rope is a critical component that connects the zipSTOP to the brake trolley, transferring braking force to arrest the motion of the rider. Proper rope selection and frequent (at least daily) inspection is important for correct operation. All textile components are subject to wear, degradation, can become damaged suddenly, and will need to be replaced periodically.

Use and failure of an improper redirection rope will result in the rider becoming disconnected from the zipSTOP. Redirection ropes may be exposed to harsh environments, heavy abrasion, shock loads and high velocities and must be able to sustain high performance. Correct selection and the integrity of the redirection rope is the most important component within a redirection system.

REDIRECTION ROPE SELECTION

In order to function properly and reliably, redirection ropes must meet stringent and rigorous requirements that cannot be satisfied by commonly available ropes. Redirection ropes must be high strength, small diameter, constructed of hydrophobic materials with minimal stretch, high abrasion and UV resistance, and have a balanced construction. Head Rush Technologies' Gorilla Rope is an optimized construction to satisfy these requirements for use as a redirection rope. The availability of suitable alternatives is limited; Gorilla Rope is recommended.



FAILURE OF THE REDIRECTION ROPE WILL DISCONNECT THE RIDER FROM THE ZIPSTOP RESULTING IN NO BRAKING APPLIED TO THE RIDER.



IN ORDER TO MEET ALL REDIRECTION ROPE REQUIREMENTS, GORILLA ROPE OR A DIRECT EQUIVALENT KERNMANTLE CONSTRUCTION (SHEATHED) ROPE A WITH BALANCED, BRAIDED CORE OF ULTRA HIGH MOLECULAR WEIGHT POLYETHYLENE MEETING ALL REQUIREMENTS MUST BE USED.



ROPES WITH ARAMID CORES ARE NOT PERMITTED TO BE USED AS REDIRECTION ROPES DUE TO POOR COMPATIBILITY AND THE INABILITY TO VISUALLY INSPECT DEGRADATION. COMMON ARAMIDS INCLUDE TECHNORA, KEVLAR, TWARON, NOMEX, ETC.



THE FOLLOWING GENERAL GUIDELINES APPLY TO ALL WEBBING, ROPES AND TEXTILES:

- Storage of rope, webbing and other textiles must be in a clean, dry area, off the floor, and away from heat and sunlight.
- Ropes must be properly terminated in accordance with the manufacturer's instructions.
- Ropes shall be retired if abused or show evidence of damage, including but not limited to: cuts, heavy abrasion, compressed spots, melting or glazing, inconsistent diameter or texture (flat, lumpy, hard spots, etc.), kinks, sheath slippage, etc.
- Never allow exposure with chemicals or high temperatures.
- If the history of the textile is unknown, replace it.
- Maintain an inspection and history record.

REDIRECTION ROPE REQUIREMENTS AND SPECIFICATIONS

If an alternative to Gorilla Rope is selected (not recommended), it must be appropriate and compatible for the intended application.

The following minimum requirements must be satisfied:

- Compatibility with the selected pulley, refer to Section: *Pulleys*
- Balanced, braided construction to minimize twisting and kinking.
- Kernmantle (sheathed core) rope construction.
- Suitability for outdoor use and the application.

REDIRECTION ROPE MINIMUM REQUIREMENTS

ALL zipSTOP MODELS

MINIMUM STRENGTH	18.7 kN
STRETCH	Low Stretch / Static
WEAR RESISTANCE	High Abrasion and UV Resistance
WATER RESISTANCE	Hydrophobic Materials
MAXIMUM DIAMETER	6 mm

Redirection Rope Minimum Requirements

Pulleys

Pulleys used within a redirection system can be used as the redirection pulley, reduction pulley, fixed support pulley, and/or as part of the traveler assembly. Proper pulley selection and frequent (at least daily) inspection is important for correct operation. Pulleys are subject to wear, loss of efficiency, corrosion and will need to be replaced periodically.

Use of an improper pulley may result in poor / abrupt braking performance, accelerated rope wear, sudden rope damage, entanglement or binding of the redirection rope or pulley itself. Pulleys may be exposed to harsh environments, heavy wear, shock loads and high velocities and must be able to sustain high performance. Correct selection and the integrity of pulleys is critical to ensuring proper performance and transfer of braking force.

REDIRECTION AND REDUCTION PULLEYS

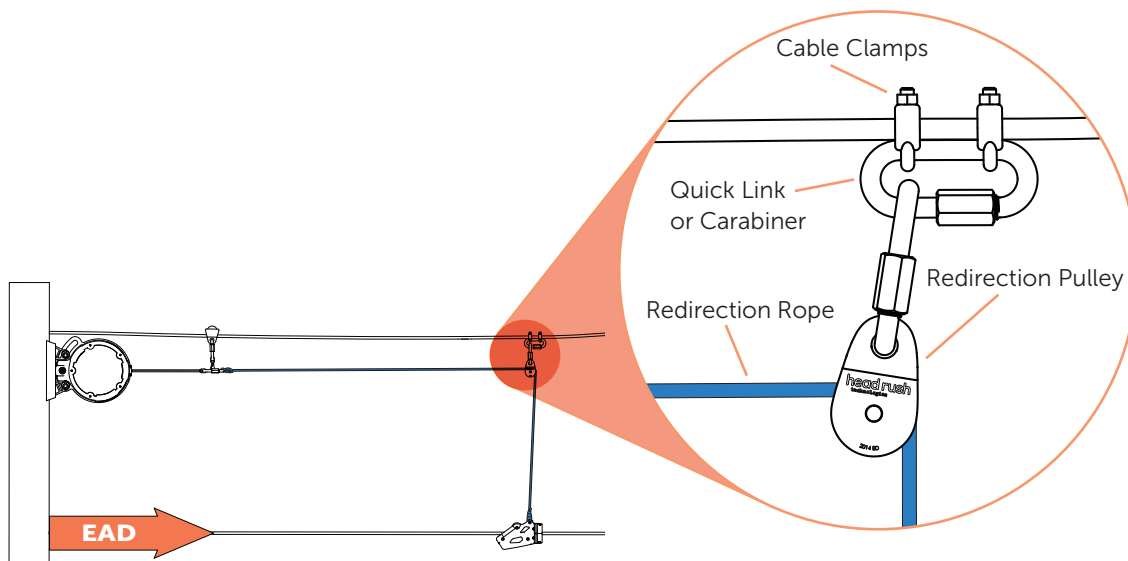
The redirection and reduction pulleys are the most critical pulleys in the redirection system. In order to function properly and reliably, these pulleys must meet stringent and rigorous requirements that cannot be satisfied by commonly available pulleys. The redirection and reduction pulleys must accommodate the small diameter (maximum 6mm) redirection rope, be corrosion resistant, have high efficiency and strength, prevent entanglement, snagging and binding. The reduction pulley must be light weight. Head Rush Technologies' Redirection Pulley is an optimized design to satisfy these requirements and accommodate the required redirection rope specifications. The availability of suitable alternatives is limited, the Head Rush Technologies' Redirection Pulley is recommended.



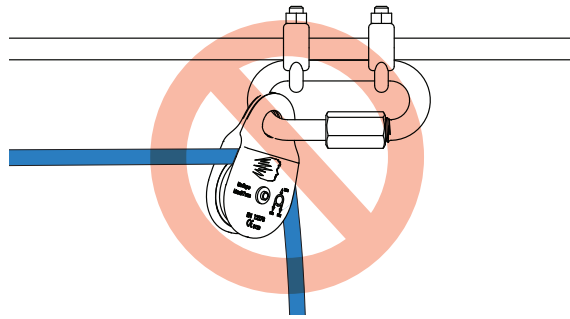
THE HEAD RUSH TECHNOLOGIES' PRECISION REDIRECTION PULLEY OR A DIRECT EQUIVALENT WHICH IS COMPATIBLE WITH THE REDIRECTION ROPE AND MEETING ALL REQUIREMENTS MUST BE USED.



THE REDIRECTION ROPE MUST BE ROUTED CLEANLY AND IN LINE THROUGH THE PULLEY SYSTEM TO PREVENT ANY TANGLING, SNAGGING OR BINDING THAT WILL HINDER RELIABLE AUTOMATIC RESET. THE REDIRECTION AND FIXED SUPPORT PULLEYS MUST BE ALIGNED, REFER TO THE FIGURES BELOW.



Redirection Pulley with Correct Alignment



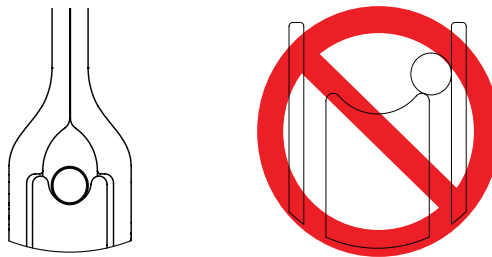
Redirection Pulley with Incorrect Alignment

If an alternative to the Head Rush Technologies' Redirection Pulley is selected (not recommended), it must be suitable for the intended application.



IF AN ALTERNATE PULLEY IS SELECTED, IT MUST SATISFY THE FOLLOWING MINIMUM REQUIREMENTS:

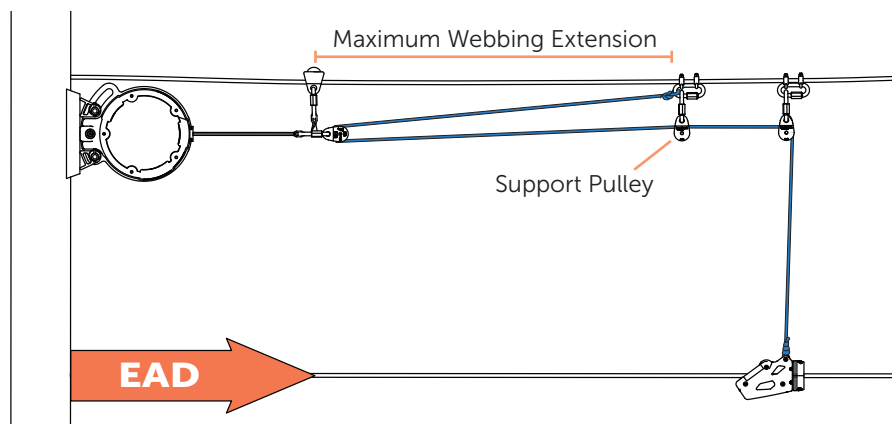
- Minimum breaking strength is 15 kN.
- Pulleys with any sheave to side plate gaps, sharp edges or other features that are susceptible to binding, snagging, entanglement and rope damage are not permitted.
- Pulleys must state the specified rope diameter is within their allowable range.
- The Pulley must be compatible with the redirection rope and the intended application. Incompatible pulleys may cause poor / abrupt braking performance, accelerated rope wear, sudden rope damage, failure of the redirection rope, entanglement or binding. Compatibility includes, but is not limited to: bend ratio (sheave diameter to rope diameter ratio – D/d ratio), sheave material, side plate – sheave gap, sharp edges, corrosion and resistance to harsh environments, etc.



Correct Pulley Size / Side Plate Gap - Incorrect Pulley Size / Excessive Side Plate Gap

FIXED SUPPORT PULLEYS

Fixed support pulleys are used to support the weight of the redirection rope, especially with 2:1 reductions. Fixed support pulleys may be attached to the overhead line at any position that does not interfere with webbing extension or traveler assembly movement, typically anywhere between the maximum webbing extension and the redirection point. A sufficient numbers of fixed support pulleys shall be used to prevent excessive sag or wind deflection.



Fixed Support Pulley Locations



FIXED SUPPORT PULLEYS MUST SATISFY THE SAME MINIMUM REQUIREMENTS AS THE REDIRECTION / REDUCTION PULLEYS, ABOVE.

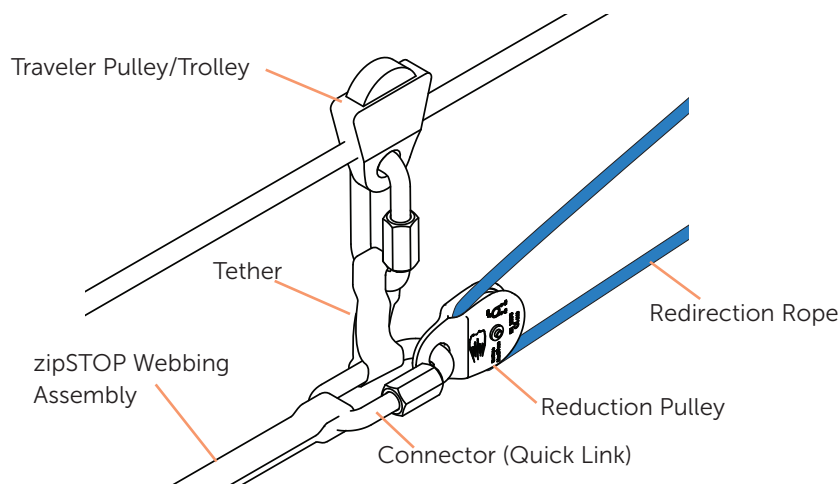
Traveler Assembly

The traveler assembly is used to support the weight of the redirection rope and hardware at the end of the zipSTOP webbing. It is comprised of at least a connector, pulley or trolley for the overhead line, tether, and reduction pulley if using 2:1 reduction system. Support from the traveler aids in proper alignment of the webbing during extraction, reliable brake system reset and reducing contact and entanglement of the webbing, ropes, cables and other objects.

The traveler pulley on the overhead line must be compatible with that cable. The tether must be of proper length to ensure the zipSTOP webbing assembly extends straight out of the device, centered on the nozzle and remains free of twists.



THE RESPONSIBLE PARTIES SHALL ENSURE PROPER OPERATION OF A TRAVELER ASSEMBLY THROUGH TESTING. TRAVELER ASSEMBLIES MUST NOT ADD RESISTANCE TO THE BRAKING SYSTEM.

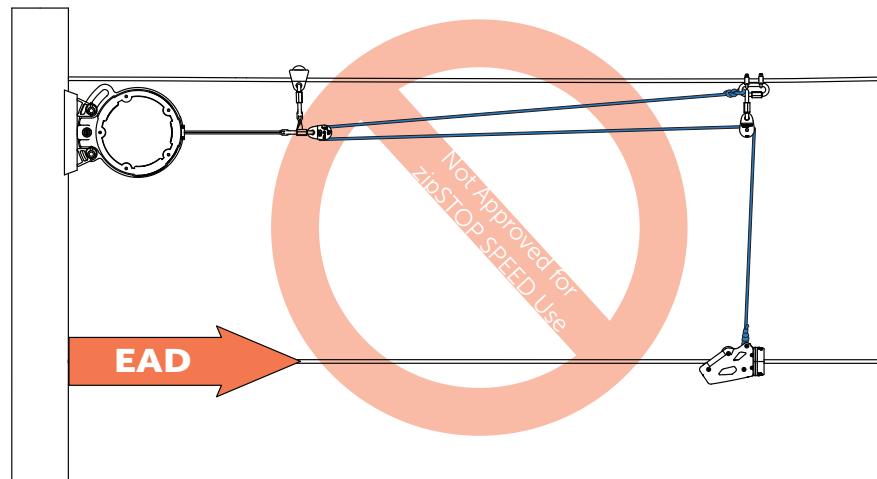


Traveler Assembly Components

2:1 Reduction Configurations

There are three possibilities of reduction ratio configurations. Consider the three figures below which show a zipSTOP SPEED with a 2:1 reduction in the proper reset position. Each figure illustrates the redirection point 40m away from the zipSTOP, accommodating the maximum possible webbing extension of 20m.

The figure below shows the redirection rope being terminated at the secondary anchor, running 40m back to the reduction pulley and 40m forward through the redirection pulley down to the brake trolley for a total of 80m of redirection rope in the system, not including the pivot height.

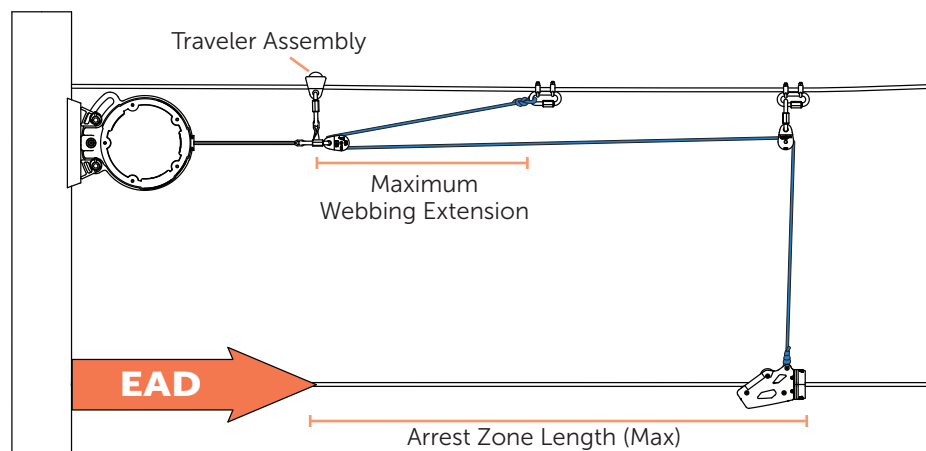


Full Length 2:1 Reduction Configuration (**zipSTOP only**)



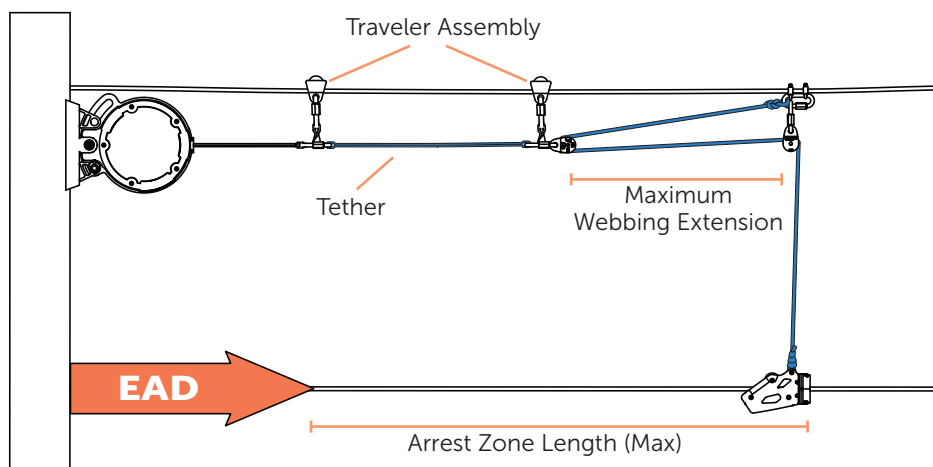
THE CONFIGURATION SHOWN ABOVE IS NOT APPROVED FOR USE WITH THE ZIPSTOP SPEED DUE TO COMPLEXITY, ADDITIONAL ROPE LENGTH AND WEIGHT HINDERING BRAKING PERFORMANCE AND AUTOMATIC RESET.

The next figure shows the redirection rope being terminated at the location of maximum extension of the zipSTOP webbing, running 20m back to the reduction pulley, 40m forward through the redirection pulley down to the brake trolley for a total of 60m of redirection rope in the system, not including the pivot height.



Half Length 2:1 Reduction Configuration (**zipSTOP or zipSTOP SPEED only**)

The final figure shows the redirection rope being terminated at the secondary anchor, running 20m back to the reduction pulley which is attached to the end of the zipSTOP webbing using a tether, 20m forward through the redirection pulley down to the brake trolley for a total of 40m of redirection rope and 20m of tether, not including the pivot height.



Tethered 2:1 Reduction Configuration (zipSTOP or zipSTOP SPEED only)

The advantages of using on the configurations in the second two figures includes a shorter length of redirection rope, less abrasion and entanglement potential, easier inspection, and a more reliable system.

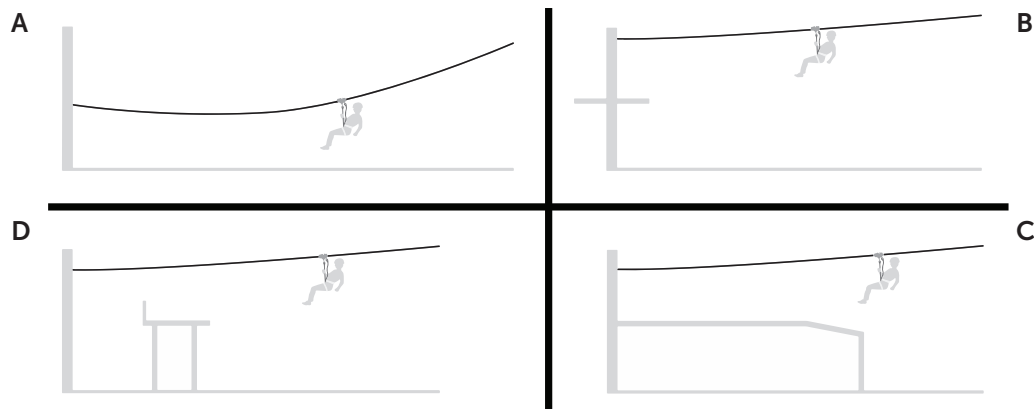
Terminal Platforms and Rider Dismount

There are four possible locations riders can dismount a zip line:

- A) along the ground anywhere within the landing area.
- B) at a small terminal platform.
- C) within a large terminal structure within all/part of the landing area.
- D) on a structure ahead of the terminal structure.

Each have advantages and disadvantages and the selection of which to use is likely contingent on cost, site specific limitations and zip line slope / catenary. Dismount location can have a large effect on rider throughput and rider recovery efforts. Structure location may facilitate inspection and maintenance of the braking components. The terminal platform location influences the zip line slope, arrival speed, and space for the EAD.

The best configuration is one that optimizes operational efficiency, rider throughput, participant safety and experience. The terminal platform should be designed for compatibility with the primary braking system, the EAD, and operational requirements.



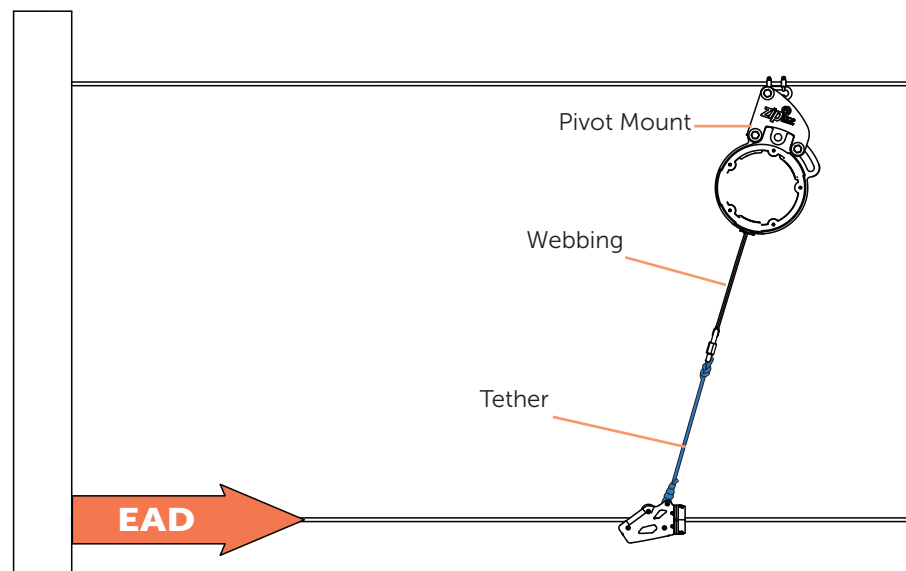
Rider Dismount Locations



ZIP LINE DESIGN INCLUDING PLATFORM AND DISMOUNT LOCATION MUST ACCOUNT FOR THE SPACE AND OTHER REQUIREMENTS OF THE EAD.

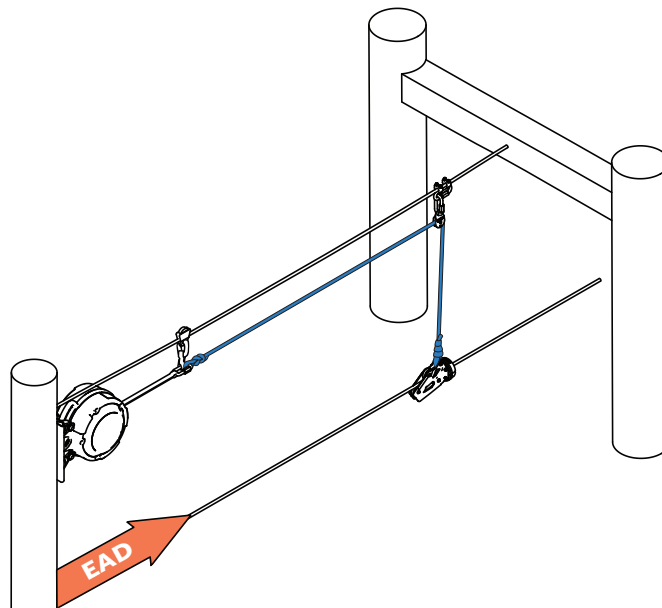
Alternate Configurations: Pivot Mount, Offset Pole, Etc.

Sometimes site specific limitations preclude the use of an overhead cable, terminal structure, etc. The below alternate configurations are provided for reference as conceptual options. Head Rush cannot recommend or approve individual installations; the Responsible Parties must qualify and approve the braking system configuration and zip line design.

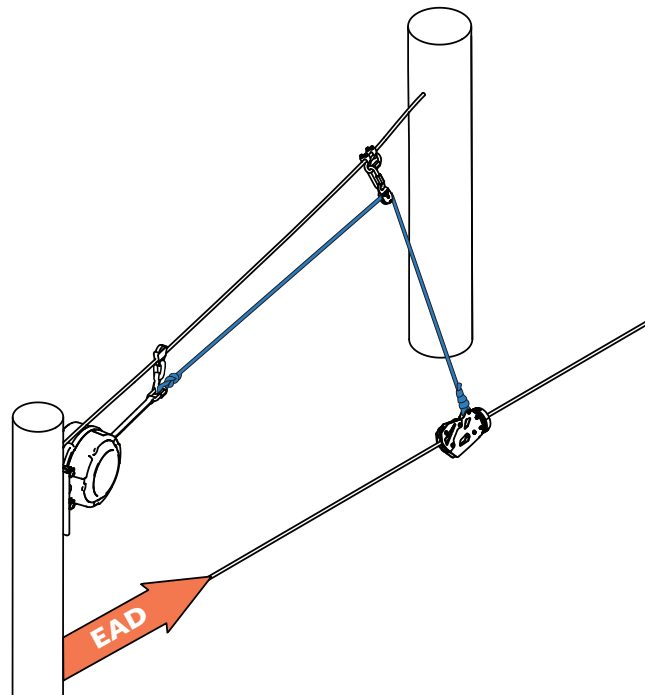


NOTE: Refer to Pivot Mount Manual

Pivot Mount



Gantry with Overhead Line

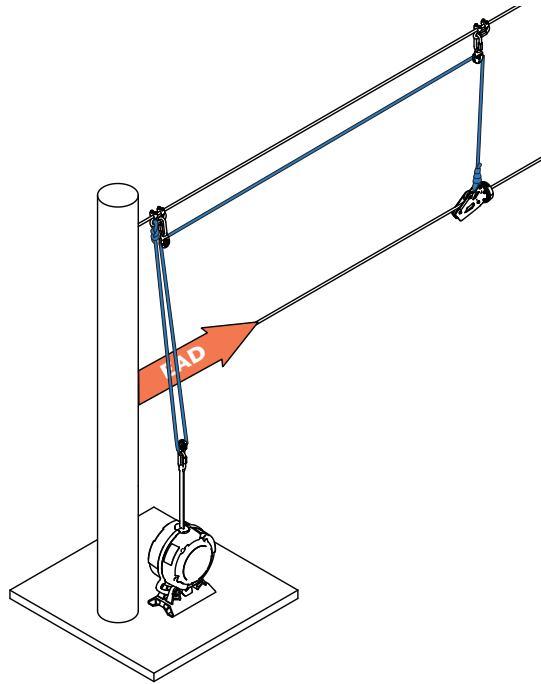


Offset Redirection Point/Secondary Anchor



STABILIZER OR DOUBLE SIDED BRAKE TROLLEY ACCESSORY REQUIRED WITH OFFSET REDIRECTION POINTS. REFER TO SECTION: ***BRAKE TROLLEY ACCESSORIES***.

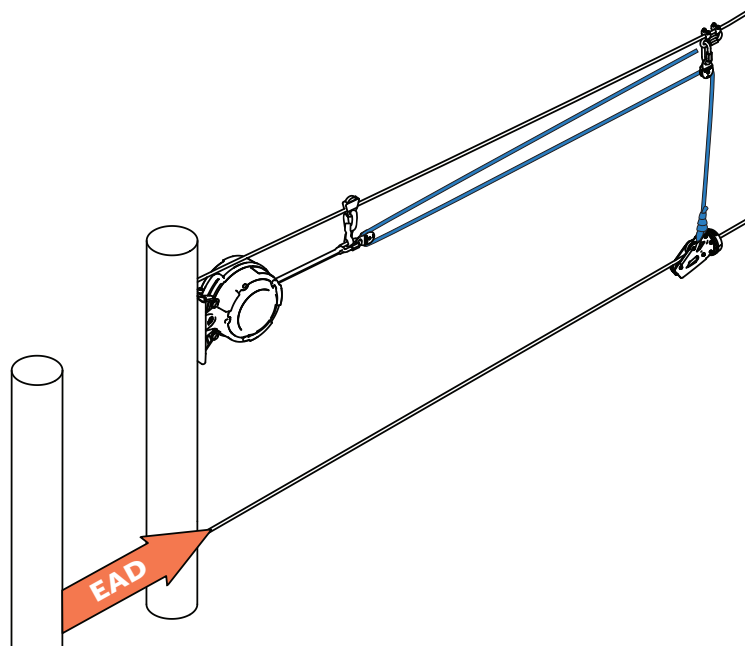
SLACK ZIP LINES WITH OFFSET REDIRECTION POINTS MAY CAUSE BINDING, WEAR, OR DAMAGE TO THE BRAKE TROLLEY, RIDER TROLLEY, REDIRECTION ROPE, ETC. THE RESPONSIBLE PARTY MUST ENSURE PROPER PERFORMANCE AT ALL TIMES.



Vertically Mounted zipSTOP



RESPONSIBLE PARTY MUST ENSURE ADEQUATE VERTICAL DISTANCE AND THAT THE REDIRECTION ROPE RUNS FREE AND CLEAR WITHOUT ABRASION OR ENGAGEMENT, ACCOUNTING FOR WIND AND OTHER VARIABLES. USE OF COUNTERWEIGHTS IS PROHIBITED.



NOTE: 2:1 Reduction in this configuration enables rider to brake/dismount behind the zipSTOP.

Non-Terminally Mounted zipSTOP

FACTORS AFFECTING BRAKING SYSTEM PERFORMANCE

Every zip line is different and is subjected to unique variables which affect ride and braking performance. During ride commissioning, the Responsible Parties must establish an operational envelope which includes setting limits and accounting for all factors affecting zip line and braking performance, refer to Section: *Device Model, Configuration and Operational Envelope*. The most important limits are commonly wind speed and direction. Overspeeding or overloading the braking system must be prevented. The following are some of the predominant variables which influence performance.



IT IS REQUIRED THAT THE RESPONSIBLE PARTIES MAINTAIN A RECORD TO HELP CORRELATE WIND DIRECTION, SPEED, RIDER WEIGHT, ETC. WITH ARRIVAL SPEED TO ENSURE LIMITS ARE NEVER EXCEEDED.

Environmental Conditions

Environmental conditions can have a large effect on arrival speeds and braking system performance. It is imperative that the Responsible Parties understand the effects that a change in environmental conditions can have and ensure provisions are in place to monitor and accommodate changes or cease operations when warranted. Environmental conditions include wind speed, wind direction, temperature, precipitation, humidity, air pressure, etc.

WIND

Wind speed and direction commonly have the largest influence on rider arrival speed. Arrival speed is the most important variable for a zipSTOP braking system as it directly affects braking, g-load and swing up. Monitoring wind speed / direction and establishing limits to halt operations to prevent an overspeed must be a part of the operational envelope and procedure for any facility using a zipSTOP. The inclusion of an anemometer, weather instrumentation, wind sock, flag, etc. at strategic locations can be used to quickly identify wind conditions. Riders arriving too fast can exceed the limits of the braking system resulting in equipment damage, serious injury or death.

Wind can also affect brake system reset. Cross winds can deflect redirection ropes so that the brake trolley does not fully reset, webbing becomes partially extended or causes rope entanglement. To help mitigate this effect, Head Rush Technologies recommends using a small diameter and lightweight rope that meets the minimum requirements, a traveler assembly and support pulleys for the redirection rope. Brightly colored tape and/or ribbons on the redirection rope adjacent to the connection with the brake trolley can be used to help visually identify proper reset; additional elements to the redirection rope must not hinder inspection. Prior to every descent, proper brake reset must be inspected.

TEMPERATURE

All zipSTOP models have been designed and tested for use in a wide range of temperatures, are rated to operate between -10°C to 40°C [14°F to 104°F] and may be stored between -20°C to 60°C [-4°F to 140°F]. Cold temperatures may slow reset due to the increase in viscosity of internal lubricants. When used in wet or freezing conditions, conditions may alter the performance of the zipSTOP device.



IF WEBBING OR ROPES BECOMES WET OR FREEZES, CEASE OPERATION IF NORMAL BRAKING OR RETRACTION/EXTENSION ARE AFFECTED.

Temperature can effect arrival speed due to changes in cable tension from thermal expansion. Thermal expansion is the tendency for objects to increase or decrease in size with changes in temperature. For zip lines spanning long distances, this will result in a change in length of the cable, tension, shape of the cable catenary and subsequently rider arrival speed. Depending on the characteristics of the cable design, a temperature change might cause an increase or decrease in arrival speed; commonly lines increase in speed with increases in tension. Zip line facilities shall monitor and record this information to understand the effect of temperature of arrival speed and adjust operational limits accordingly.

WET AND HUMID CONDITIONS

All zipSTOP models have been designed and tested for use in a wide range of conditions including wet and humid environments. The zipSTOP webbing, other textiles and hardware may wear faster if used for prolonged periods in these conditions; webbing / component inspection and replacement frequency shall be increased accordingly. Ensure adequate retraction as operation may be affected in these environments. Arrival speed commonly increases when operating on wet zip lines; adjust operational limits accordingly. Do not store device in a wet condition, refer to Operation and Maintenance Manual.

HARSH ENVIRONMENTS

All zipSTOP models may be used in harsh environments including marine/salt water, sun exposure, dust, changing weather, etc. The zipSTOP webbing, other textiles and hardware may wear faster if subjected to these conditions for prolonged periods; webbing / component inspection and replacement frequency shall be increased accordingly. Extended exposure to salt and harsh environments may cause corrosion. If operating in a salty environment, visual inspection of the device including removing the side covers to inspect internal components shall be conducted weekly. If red rust is found, the device must be returned to an Authorized Servicing Agent for recertification. White scaling is acceptable and does not require a recertification.

The zipSTOP CANNOT be used in any chemical or caustic environment including, but not limited to: exposure to acids, bases, chlorine, caustics, etc. These chemicals will degrade the strength of textiles and accelerate the rate of corrosion which may not be inspectable.

Pivot Height

Pivot height is the distance between the redirection pulley and the reset position on the zip line cable and can have a significant effect on initial brake force and total braking distance. The minimum pivot height is 1m, on an unweighted zip line for all zipSTOP models and configurations. Using a pivot height less than 1m will result in abrupt braking on the rider and increase the chance of entanglement.



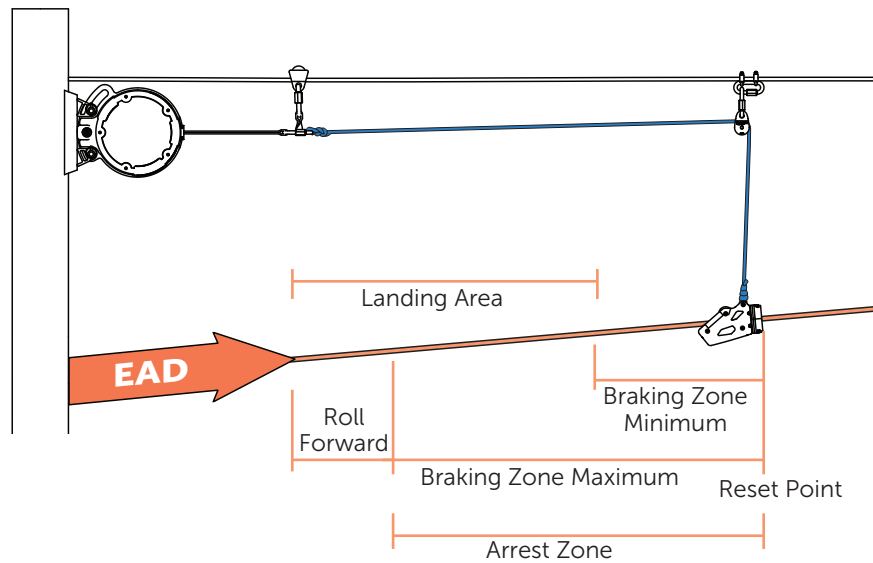
THE MINIMUM PIVOT HEIGHT FOR ALL ZIPSTOP MODELS AND CONFIGURATIONS IS 1M.

Increasing the pivot height slows down and reduces the onset of braking applied to the rider, reducing g-force, swing up and increasing braking distance. Two potential benefits of a longer pivot height would be to accommodate lighter weight riders and/or reduce g-load and swing up. The downside of increased pivot height are longer braking distances and a farther redirection point.

Zip Line Slope

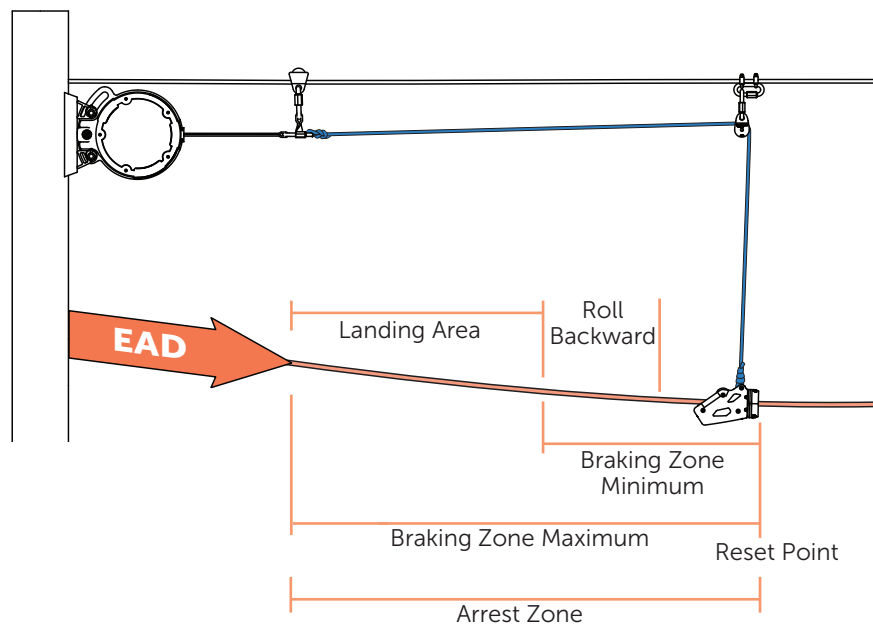
Three zip line catenary curves at the end of the line are possible: positive line slope, negative line slope and neutral line slope. The slope of the line will influence the total braking distances. The optimal line slope is dependent on zip line configuration including terminal platform and dismount location.

Positive line slope is frequently the result of a catenary where the belly is behind the reset position and/or on high tension lines; riders will accelerate until they contact the brake trolley. A positive line slope may aid rider recovery due to the assistance of gravity. On positive line slope installations, braking distance may be longer than braking distance calculations predict.



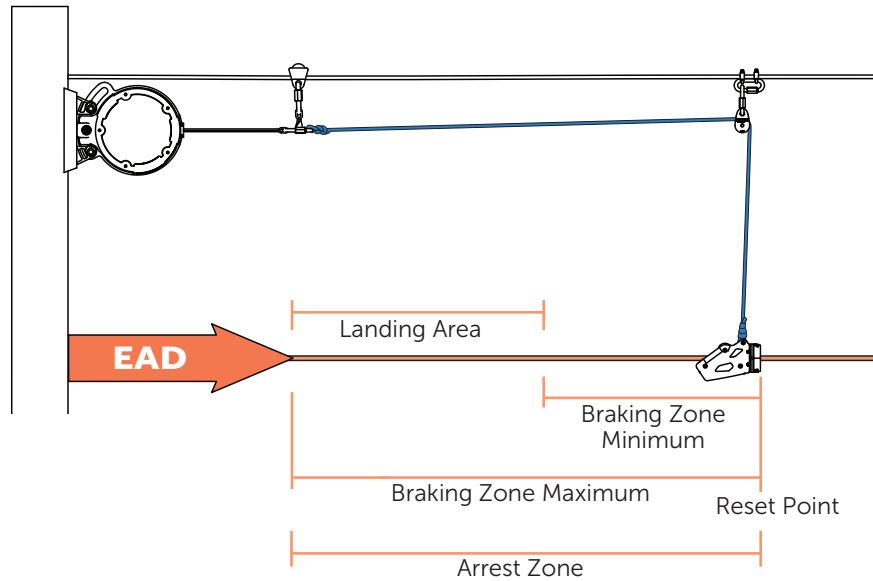
Positive Line Slope

Negative line slope is frequently the result of a catenary with a belly ahead of the reset position; riders typically reach peak speed then slow down prior to impact with the brake trolley. Negative line slope can make recovery at a terminal platform challenging due to gravity. On negative line slope installation, braking distance may be shorter than braking distance calculations predict; riders may roll backwards.



Negative Line Slope

A neutral line slope is typically the result of a catenary where the belly coincides with the arrest zone; rider may reach peak or constant speed at brake initiation and typically don't move much after being stopped by the braking system.



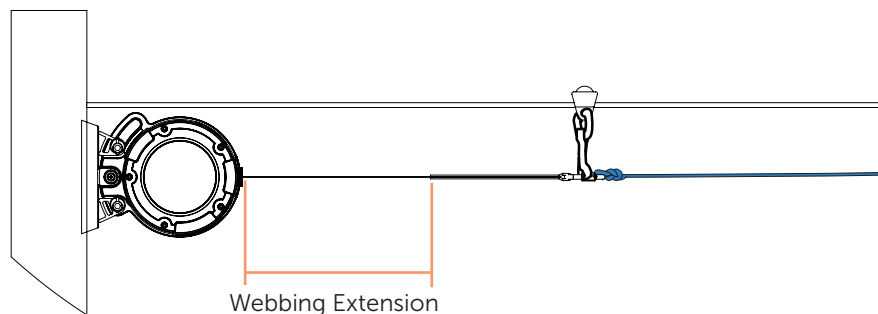
Neutral Line Slope

Webbing Extension

The zipSTOP initial braking force is increased if the webbing is extended from the device prior to braking. This is caused by a reduction in diameter of the internal webbing stack causing an increase in rotational speed of the brake.



THE WEBBING SHALL NOT BE EXTENDED FROM THE ZIPSTOP BY MORE THAN 1M [3.3 FT] WHEN THE FACILITY MAXIMUM WEIGHT IS HANGING ON THE ZIP LINE AT THE RESET POSITION. ON AN UNWEIGHTED ZIP LINE, PRIOR TO A RIDER DESCENT, THE BRAKING LINE MAY BE EXTENDED FROM THE ZIPSTOP A MAXIMUM 0.3M [1FT].



Webbing Extension

Other Factors: Cable Deflection, Redirection Rope Stretch, Sag

All horizontally suspended cables hang with a curvature called a catenary. The shape of the catenary is dictated by the weight and tension of the cable. When a load is applied to a point on the cable, such as the weight of a zip line rider, the cable deflects. How much the cable deflects is dependent on the load, catenary and cable properties. For zip lines and redirection ropes, there are several scenarios where cable deflection can have an effect on brake system performance.

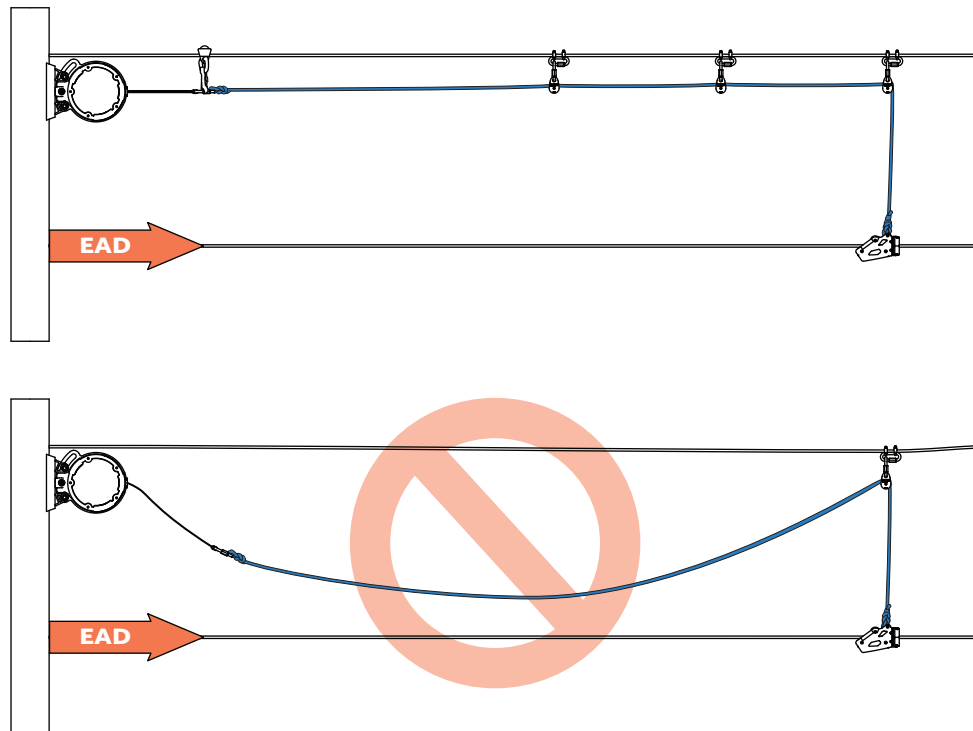
When a rider arrives at the brake reset position, the zip line cable will deflect, causing an increase in pivot height. Heavier weights will deflect the cable more causing an increase in pivot height. This is exaggerated for "slack cables," where lower cable tensions will result in larger cable deflections. This deflection may take-up sag in the redirection rope or extend the webbing from the zipSTOP.

The redirection rope will also have some degree of catenary, often referred to as redirection rope sag. Traveler assemblies and fixed support pulleys shall be used as required to support the redirection rope and keep sag to a minimum.

When a rider impacts the brake trolley, they traverse the zip line until all redirection rope sag is taken up; at this point, the zipSTOP becomes engaged. Because the rider has passed the reset point at brake initiation, the pivot angle has increased, increasing the initial braking force on the rider.



REDIRECTION SYSTEMS MUST NOT CONTAIN EXCESSIVE SAG IN ORDER TO PREVENT HIGH G-LOADS, SWING UP AND ABRUPT BRAKING.



Redirection Rope Sag

New redirection ropes may stretch and knots settle over time, adding length and sag to the redirection system. Inspection and adjustment may be required. The zip cable may also stretch and sag affecting the catenary and arrival speed; the Responsible Parties shall take this into account as required.

MODEL, CONFIGURATION AND OPERATIONAL ENVELOPE

Selecting and correctly installing the proper zipSTOP model and configuration is critical to achieve desired braking performance. Determining the operational envelope and testing the braking system is required to verify performance and commission the zip line. Testing the braking system in accordance with this manual is one of the most important steps of any zipSTOP installation. The sections below outline considerations and procedures to complete this process; additional criteria may also be required.

Weight Range

All zipSTOP models can accommodate a rider weight range of 15-150 kg [33-330 lbs]. Rider weight is the combined weight of the rider and all attached gear that traverses the zip line, including harness, helmet, rider trolley, etc. Rider weight is one factor which can heavily contribute to arrival speed; heavier riders typically arrive faster than lighter weight riders and require a longer braking distance, however, it is possible that an intermediate weight rider arrives faster than the heaviest weight rider due to wind drag; this scenario must be tested. If arriving too fast, it may be possible to reduce arrival speed by reducing rider weight or rider position. It is necessary to know the rider weight range before configuring the zipSTOP.



THE MAXIMUM RIDER WEIGHT MUST NEVER BE EXCEEDED.

Arrival Speed

Rider arrival speed is affected by many variables, including, but not limited to: catenary, zip line length, rider weight, wind drag due to rider position, wind direction / speed, and friction. Arrival speed is the rider speed at the moment of impact with the brake trolley. The maximum allowable arrival speed is dependent on the zipSTOP model / configuration; refer to Section: **Models, Specifications and Parts: zipSTOP and Brake Trolley**. It is necessary to know the minimum and maximum rider speeds across the weight range prior to configuring the zipSTOP. The primary braking system and EAD maximum arrival speed must never be exceeded.



THE MAXIMUM ARRIVAL SPEED MUST NEVER BE EXCEEDED FOR THE PRIMARY BRAKING SYSTEM AND EAD IN ANY CONDITION.

Determining Device Model, Reduction Ratio and Configuration

In order to select the correct device model / configuration, the braking performance across the operating envelope should be estimated initially and must be confirmed through testing. The operating envelope is the set of limits and conditions which zip line operations must stay within to ensure proper operation of the zip line and braking systems, particularly arrival speed. Design of new zip line braking systems commonly use estimations until arrival speed and other variables are tested and measured.

Use the following rider weight - arrival speed combinations to determine the proper device model, reduction ratio and configuration:

- Max arrival speed, max weight
- Max arrival speed, min weight
- Min arrival speed, min weight
- Max arrival speed, other weight – if max speed is not for max weight

The above conditions shall include allowances for worst case scenarios including at least:

- Wind direction
- Wind speed
- Rider position / orientation (seated, reclined, prone, etc.)
- Other environmental / operational variables

Any conditions affecting arrival speed, braking system performance or the limits of the operational envelope must be considered. When test data is not available for all scenarios / limits of the operating envelope, estimations shall be used for initial design with provisions and procedures established to prevent operating outside the operating envelope. Refer to Section: **Testing the Braking System** for additional information.



THE DOCUMENTED OPERATING PROCEDURE MUST INCLUDE PROVISIONS AND PROCEDURES TO PREVENT OPERATION OUTSIDE THE OPERATIONAL ENVELOPE. THIS MUST INCLUDE, BUT IS NOT LIMITED TO: WIND SPEED, WIND DIRECTION, RIDER POSITION, ENVIRONMENTAL AND OTHER CONDITIONS WHICH EFFECT THE ARRIVAL SPEED AND OTHER ESTABLISHED LIMITS.



EVALUATION OF BRAKING PERFORMANCE SHALL INCLUDE AT LEAST THE BRAKING DISTANCE AND RIDER SWING UP.



TESTING MUST BE CONDUCTED IN ACCORDANCE WITH THIS MANUAL, REFER TO SECTION: **TESTING THE BRAKING SYSTEM**.

To select the proper device:

- Select device model/reduction ratio which has a maximum device speed *higher* than the maximum arrival speed in all conditions. Maximum device speed must be sufficiently higher than maximum arrival speed to account for variability and other factors.
 - Max Arrival Speed < 36 kph [22 mph] → zipSTOP 1:1
 - Max Arrival Speed < 60 kph [37 mph] → zipSTOP IR, zipSTOP 2:1
 - Max Arrival Speed < 72 kph [45 mph] → zipSTOP SPEED 2:1
- Measure Pivot Height.
- Calculate estimated braking distance for above rider weight - arrival speed combinations, refer to Section: **Calculating zipSTOP Braking Distances / Braking Distance Charts**.
- Using the braking distances calculated in previous step, determine the redirection point location.
 - Consider at least the following when selecting the redirection point location: EAD, rider dismount location, webbing extension, landing area, rider recovery, inspectability of reset and components, etc.



DO NOT USE THE ZIPSTOP IF ARRIVAL SPEED CANNOT BE KEPT BELOW THE MAXIMUM ARRIVAL SPEED AT ALL TIMES IN ALL CONDITIONS.

Calculating zipSTOP Braking Distances / Braking Distance Charts

There are two methods of calculating braking distance, an online calculator and braking distance charts. Both methods are for initial estimations only and will vary based on site specific factors. The online calculator takes into account the effect of pivot height whereas the charts are based on the minimum 1m pivot height. Testing is required in accordance with this manual.

Head Rush Technologies' online distance calculator: <https://headrushtech.com/zipstop-zip-line-brake/braking-distance-calculator.html>

Braking Distance Charts

To use the braking distance charts for each weight-arrival speed combination:

1. Find the arrival speed on the horizontal axis.
2. Draw a vertical line to the weight curve.
3. Draw a horizontal line to the vertical axis.
4. The intersection with vertical axis is the estimated braking distance for that weight and speed.
5. Calculate Braking Line Extension = Braking Distance / Reduction Ratio.
6. Repeat for rider weight - arrival speed combinations, above:
 - a. Arrival speed and weight are within device limits.
 - b. Weight - Speed is above the BDmin line . Use caution if operating in the shaded area.
 - c. Braking line extension is less than the device maximum webbing extension.



AREAS ON THE CHART BELOW THE BDMIN LINE ARE LIKELY TO RESULT IN ABRUPT BRAKING AND EXCESSIVE RIDER SWING UP; OPERATION IN THIS AREA IS NOT ALLOWED. AREAS IN THE GREY REGION ABOVE THE BDMIN LINE MAY RESULT IN HIGHER BRAKING FORCES AND RIDER SWING UP AND SHALL BE TESTED AND EVALUATED AS PART OF RIDE COMMISSIONING.

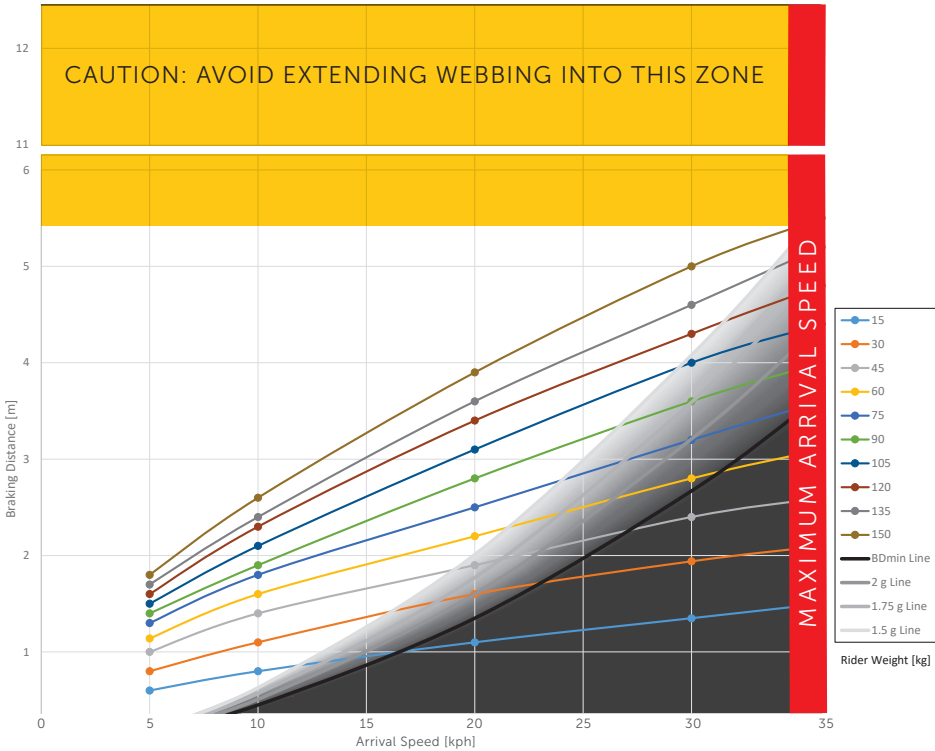


THE MAXIMUM ARRIVAL SPEED MUST NEVER BE EXCEEDED FOR THE PRIMARY BRAKING SYSTEM AND EAD IN ANY CONDITION.

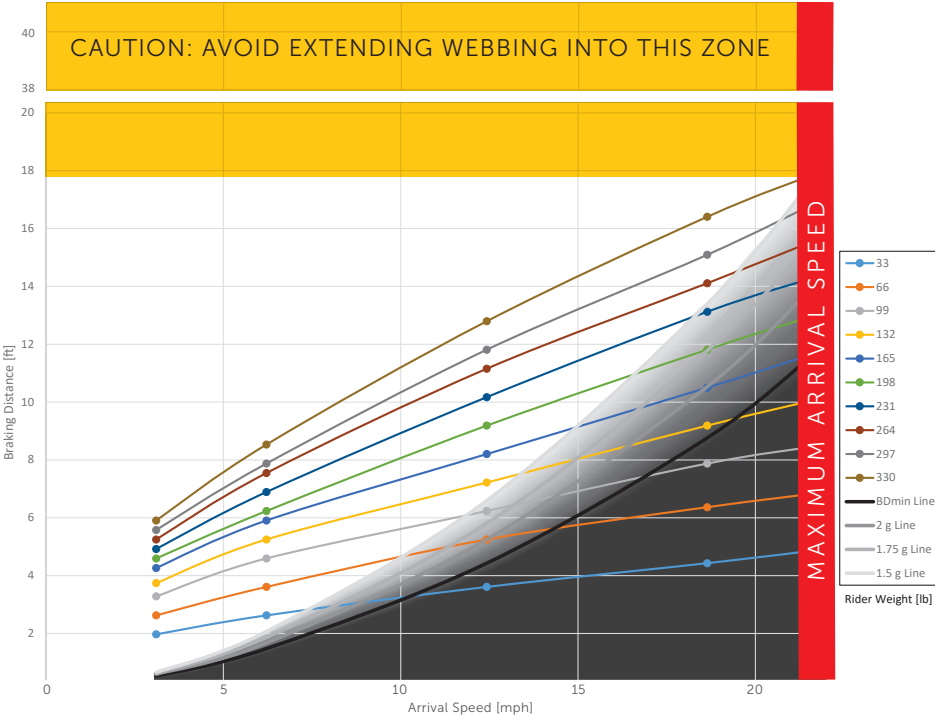


EXTENDING THE WEBBING INTO YELLOW ZONE (REFERENCE CHARTS PG. 39-42) WILL VOID SPRING WARRANTY.

ZIPSTOP 1:1 REDIRECTION

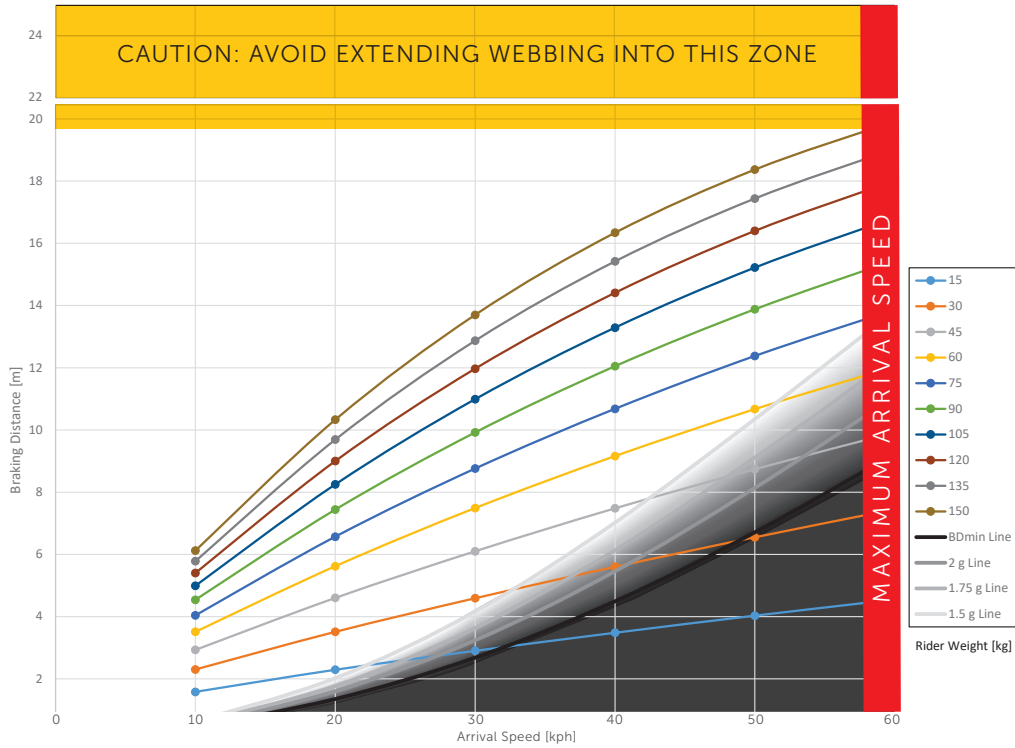


zipSTOP 1:1 Redirection Braking Distance - Metric

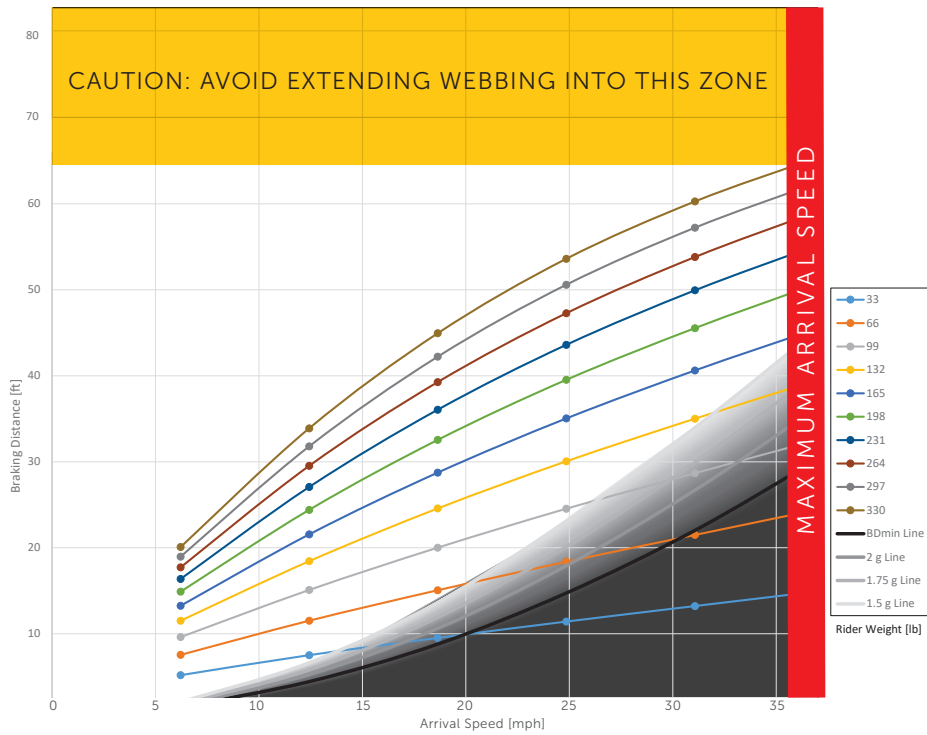


zipSTOP 1:1 Redirection Braking Distance - Imperial

ZIPSTOP 2:1 REDUCTION

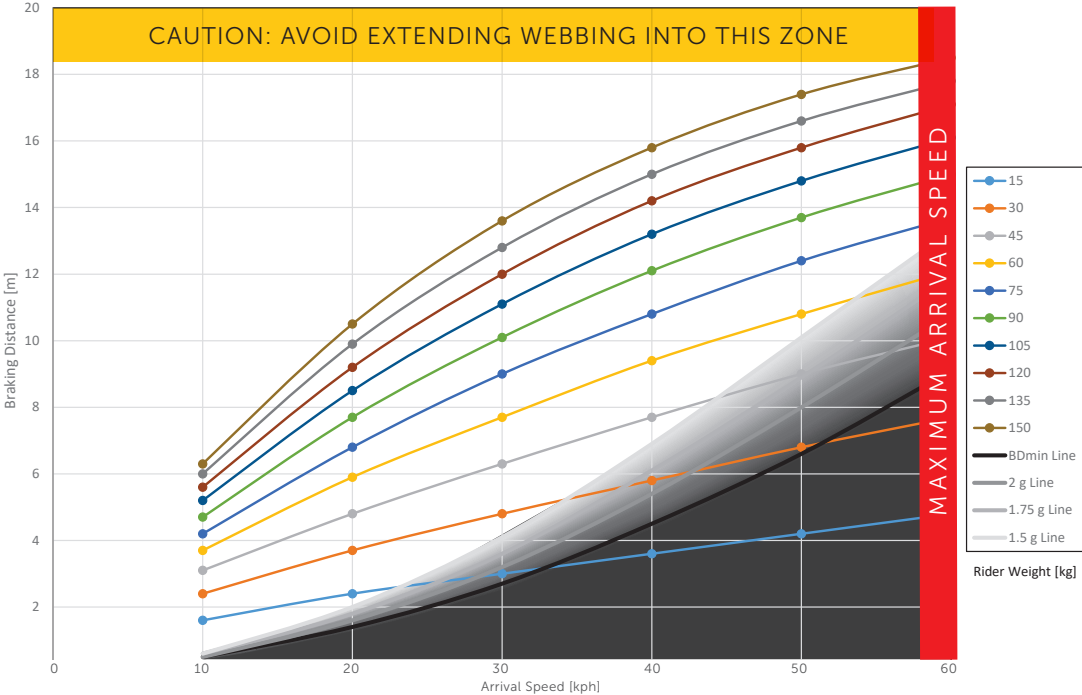


zipSTOP 2:1 Reduction Braking Distance – Metric

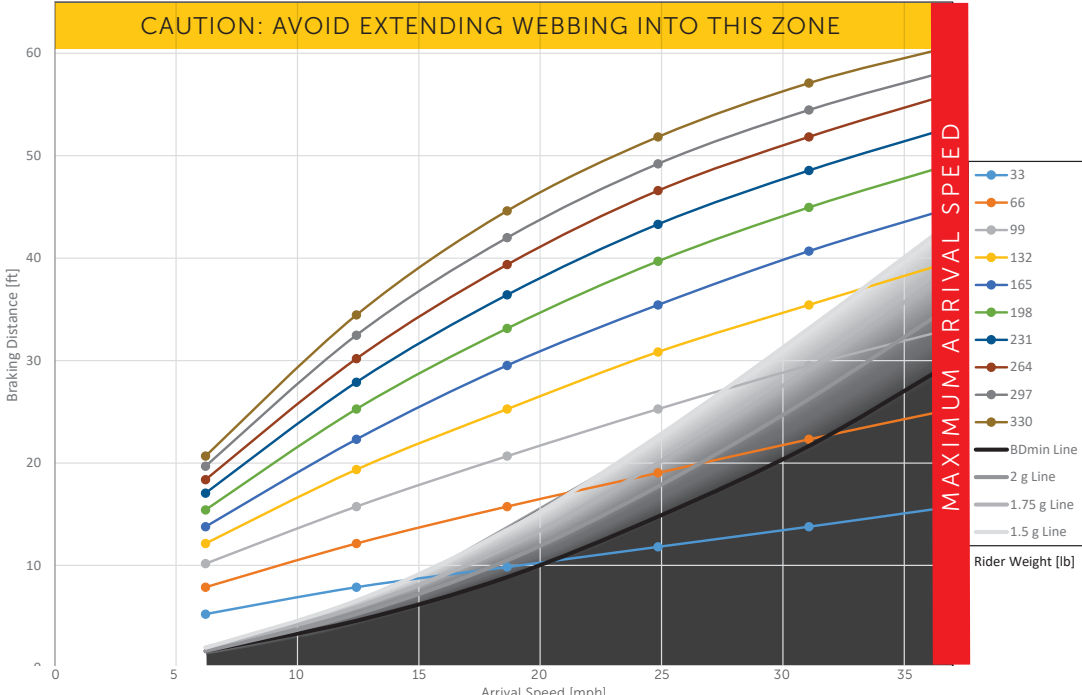


zipSTOP 2:1 Reduction Braking Distance - Imperial

ZIPSTOP IR 1:1 REDIRECTION

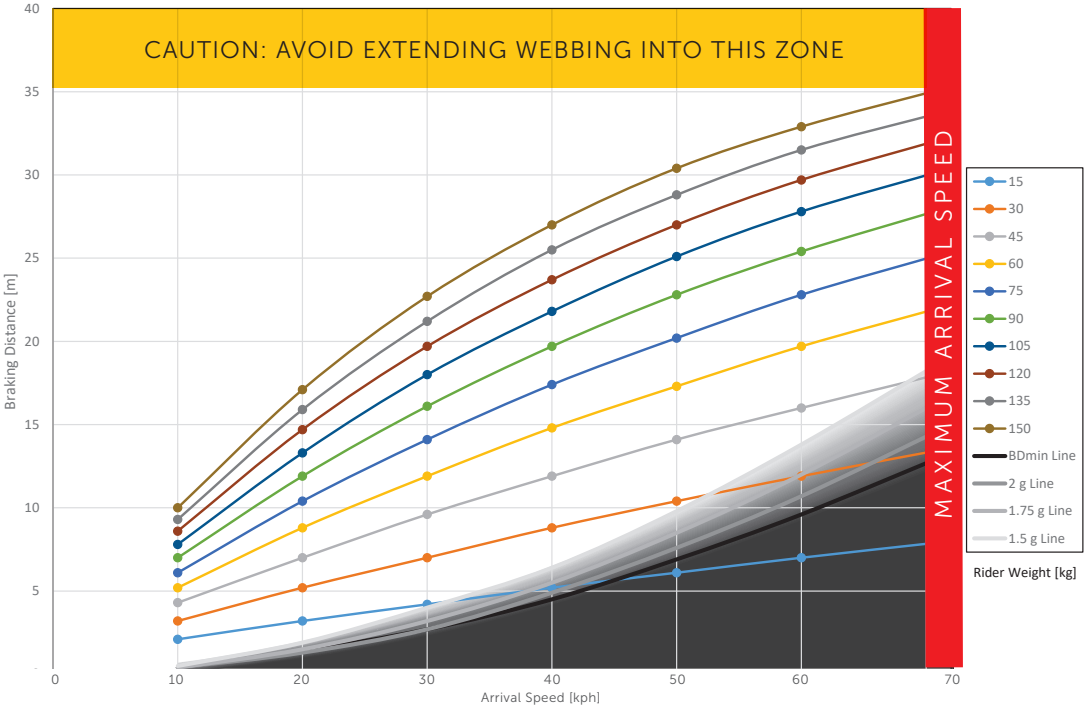


zipSTOP IR 1:1 Redirection Braking Distance – Metric

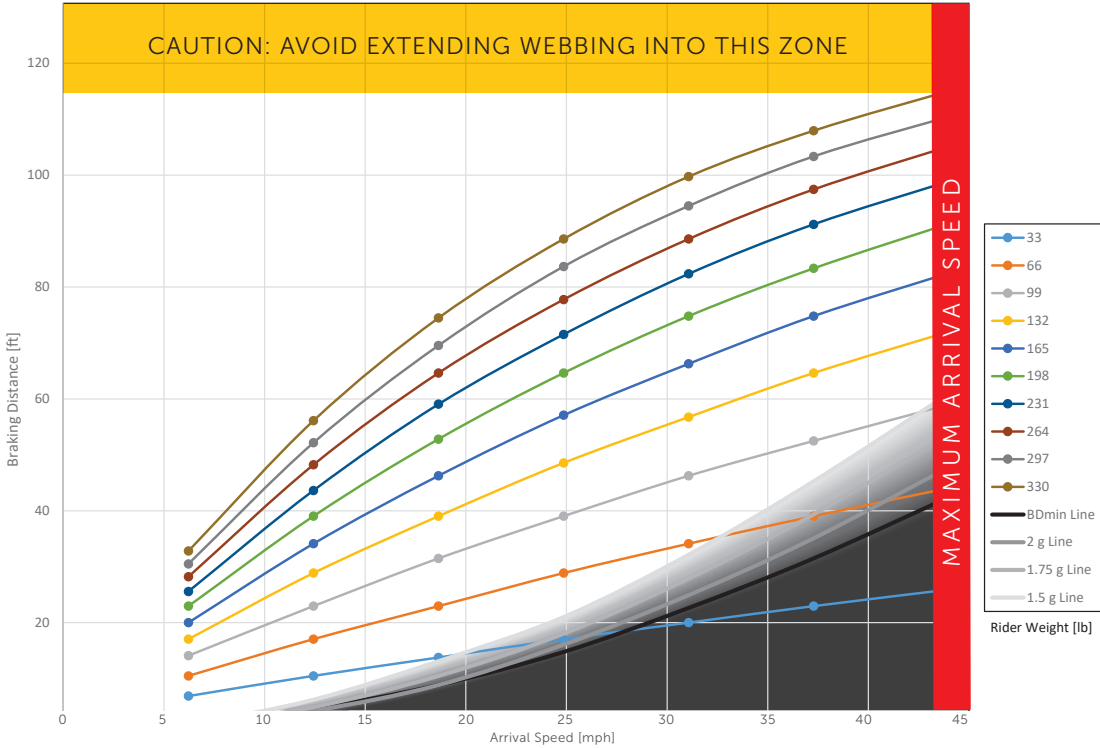


zipSTOP IR 1:1 Redirection Braking Distance - Imperial

ZIPSTOP SPEED 2:1 REDUCTION



zipSTOP SPEED 2:1 Reduction Braking Distance – Metric



zipSTOP SPEED 2:1 Reduction Braking Distance - Imperial

INSTALLING THE BRAKING SYSTEM COMPONENTS

Once the device model, reduction ratio, and redirection point location have been determined the zipSTOP and associated components can be installed and tested. The following steps outline the predominate actions and hardware required to install the remainder of the system.

EAD Present and Tested



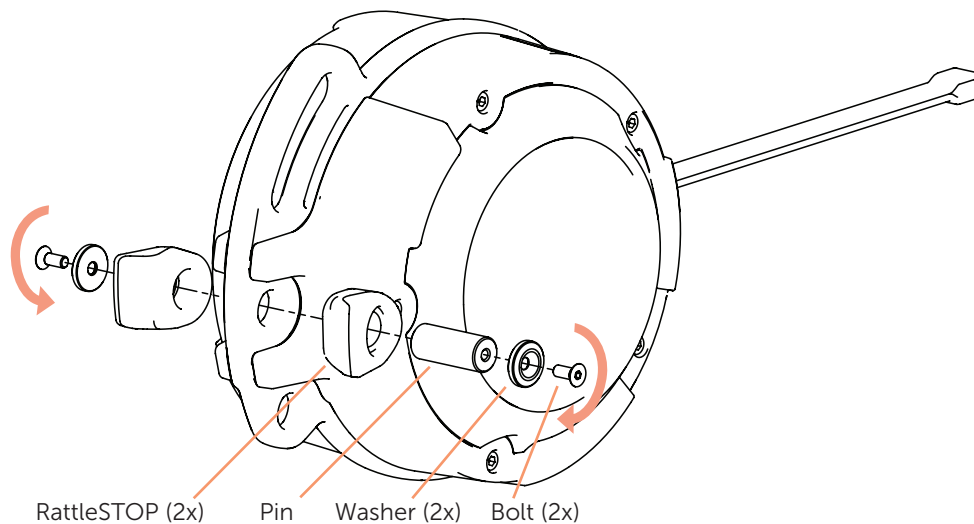
ENSURE AN EAD THAT PREVENTS SERIOUS INJURY OR DEATH, MAKES THE BRAKING SYSTEM FAIL-SAFE, AND MEETS THE REQUIREMENTS SPECIFIED IN THIS MANUAL IS PRESENT AND SUFFICIENT TO ARREST ALL WEIGHTS AND SPEEDS. AN EAD AND/OR FAIL-SAFE COUNTERMEASURES IS REQUIRED FOR ALL DESCENTS. TESTING IN ACCORDANCE WITH THIS MANUAL IS REQUIRED.

Initial Configuration and Distances

Always start with a braking distance/redirection point and device model to accommodate the upper limits of the operational envelope. Hedge toward an initial set up with allowance to prevent overextending the zipSTOP webbing or undesired contact with the EAD. The redirection point can be moved to suit actual performance.

Install the RattleSTOP

The RattleSTOP assembly utilizes an elastomeric bushing to reduce vibration between the zipSTOP device and mounting base. Install the assembly as shown in the below figure prior to installing the device onto the mounting base. Tighten the bolts until firmly seated.



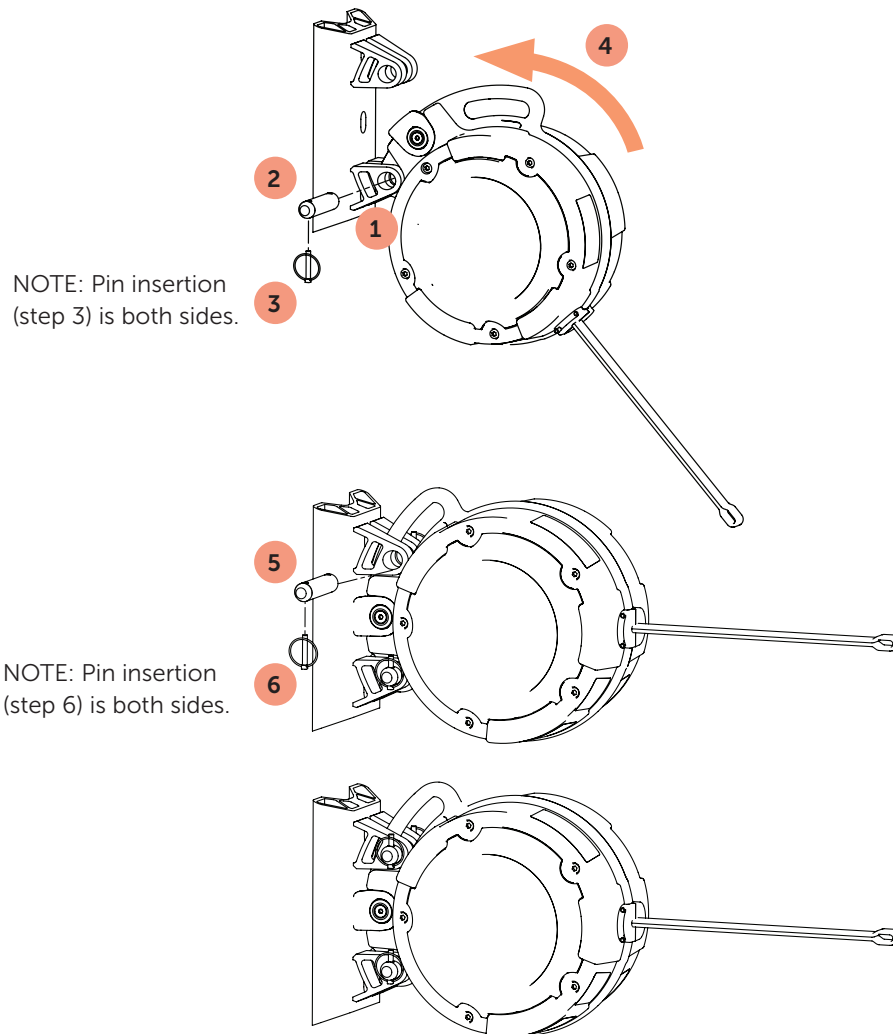
RattleSTOP Assembly

Install zipSTOP onto Mounting Base

The zipSTOP can be installed onto the mounting base by following the below steps. Refer to Section: **zipSTOP Base Mounting** for instructions on how to install the base onto the primary anchor point. A padlock may be used in place of the lynch pins to secure the device in place.

Installation Procedure:

1. Align bottom hole of central plate with bottom hole of mounting base.
2. Insert mounting pin through holes.
3. Insert lynch pins through end holes of mounting pin.
4. Pivot zipSTOP device up to align handle with top mounting base hole.
5. Insert mounting pin through holes.
6. Insert lynch pins through end holes of base pin.



zipSTOP Installation onto Mounting Base

Brake Trolley

The Head Rush Brake Trolley model ZT125-17 captures the zip line and rolls along three sheaves. Several accessories are available from Head Rush Technologies for the brake trolley including a stabilizer, double sided brake, and catch accessory.



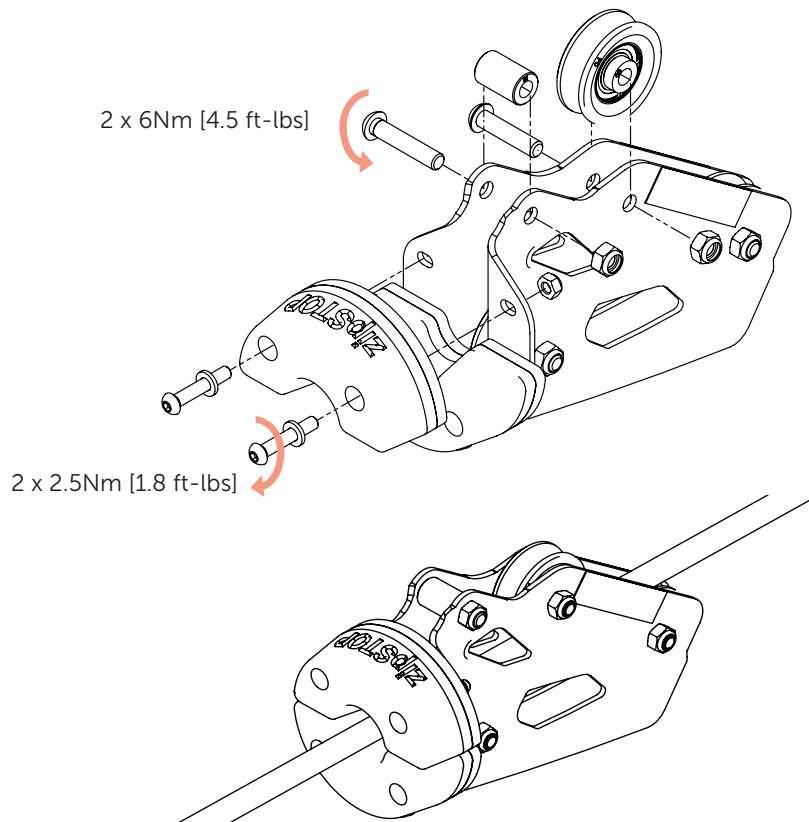
ALWAYS ENSURE THE CORRECT SIZED SHEAVES ARE USED FOR THE CABLE AND ARE COMPATIBLE WITH THE CABLE TYPE. ENSURE ALL FASTENERS ARE PROPERLY TIGHTENED PRIOR TO USE, DO NOT OVERTIGHTEN FASTENERS.



OFFSET REDIRECTION POINTS REQUIRE THE USE OF THE STABILIZER OR DOUBLE SIDED BRAKE ACCESSORIES.

Installation Procedure:

1. Remove the top bumper, sheave and spacer.
2. Place trolley on zip line with bumpers facing direction of approaching rider.
3. Reinstall components.
4. Check that the Brake Trolley rolls smoothly on the line and without excessive play.



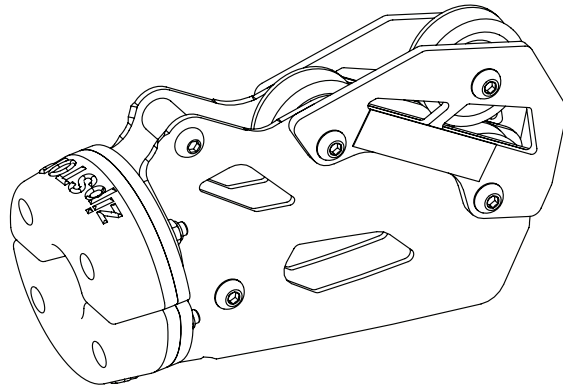
Brake Trolley Installation

Brake Trolley Accessories

Several accessories are available for use with different zip line configurations. Complete brake trolley assemblies and retrofit kits are available.

STABILIZER ACCESSORY

The Stabilizer Accessory adds a fourth sheave to the brake trolley which provides additional capture of the zip line cable. This additional constraint prevents rubbing between of the zip line on the inside of the brake trolley.



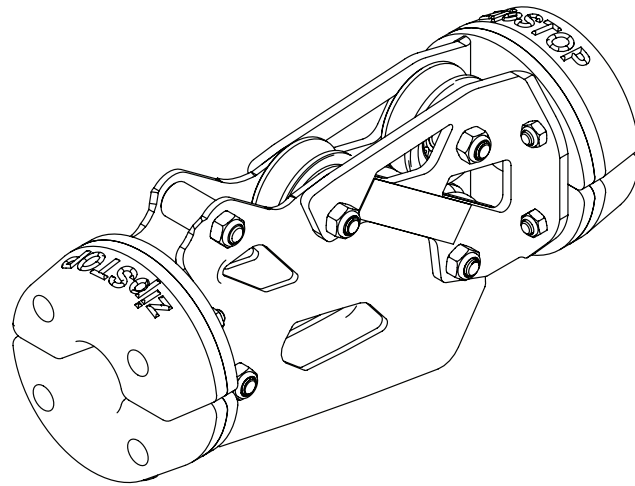
Stabilizer Accessory



THE STABILIZER ACCESSORY MUST BE USED WITH OFFSET REDIRECTION POINTS.

DOUBLE SIDED BRAKE ACCESSORY

The Double Sided Brake Accessory adds a fourth sheave and second set of BumpStops to the brake trolley. The additional BumpStops add a contact surface for components behind the brake trolley such as an EAD to prevent binding and damage to either component.



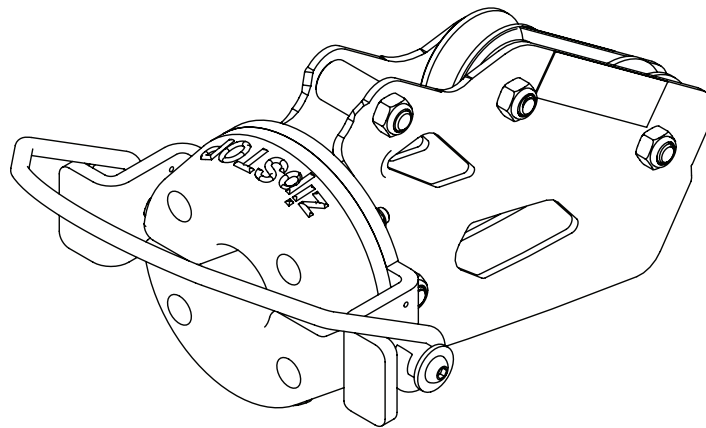
Double Sided Brake Accessory



COMPATIBILITY WITH COMPONENTS BEHIND THE BRAKE TROLLEY MUST BE VERIFIED BY THE RESPONSIBLE PARTY.

CATCH ACCESSORY

The catch accessory provides an interlocking interface between the brake trolley and compatible Head Rush Technologies' rider trolleys to facilitate rider recovery. The catch accessory can also be used with either the Stabilizer or Double Sided Brake Accessory.



Catch Accessory



THE CATCH ACCESSORY IS DESIGNED FOR USE WITH CATCH EQUIPPED HEAD RUSH TECHNOLOGIES' RIDER TROLLEYS.

Redirection Rope Installation

1:1 REDUCTION RATIO

1. Terminate one end of the redirection rope at the brake trolley.
2. Pass the rope through the redirection pulley.
3. Run the rope toward the zipSTOP, passing through any support pulleys along the way. Support pulleys may be installed later.
4. Pull the redirection rope taught so the brake trolley is in the reset position.
5. Without over-extending the webbing from the zipSTOP, terminate the redirection rope on a suitable connector at the end of the webbing.
 - a. Deflection of the zip line or overhead cable due to weight during installation may affect the redirection rope distance.
6. Install the traveler assembly as shown, Section: **Traveler Assembly**. Install support pulleys if required.
7. Check for reliable automatic reset:
 - a. Pull the brake trolley toward the terminal platform and release.
 - b. Check that the system completely resets with the webbing properly retracted, brake trolley returning to the reset position and no entanglements occur.
 - c. If retraction is inadequate, a traveler assembly and/or additional support pulleys may be required.
8. Repeat Step 7 for different distances between the minimum and maximum braking distance.

2:1 REDUCTION RATIO

1. Terminate one end of the redirection rope at the brake trolley.
2. Pass the rope through the redirection pulley.
3. Run the rope toward the zipSTOP, passing through any support pulleys along the way. Support pulleys may be installed later.
4. Pass the redirection rope through the reduction pulley.
5. Pull the redirection rope away from the zipSTOP, toward the termination point.
6. Pull the redirection rope taught so the brake trolley is in the reset position with the webbing properly retracted.
7. Without over-extending the webbing from the zipSTOP, terminate the redirection rope on a suitable connector at the termination point.
 - a. Weight applied to the zip line or overhead cable during installation may affect the redirection rope distance.
8. Install the traveler assembly as shown, Section: **Traveler Assembly**. Install support pulleys if required.
9. Check for reliable automatic reset:
 - a. Pull the brake trolley toward the terminal platform and release.
 - b. Check that the system completely resets with the webbing properly retracted, brake trolley returning to the reset position and no entanglements occur.
 - c. If retraction is inadequate, a traveler assembly and/or additional support pulleys may be required.
10. Repeat step 9 for different distances between the minimum and maximum braking distance.

Automatic Reset

A properly configured redirection system will have reliable, automatic reset. Reset means the zipSTOP webbing and brake trolley return to the reset position and the redirection rope runs free and clear without entanglement. Proper braking system reset may be affected due to rope entanglement or other interference and must be inspected prior to every descent.



A ZIPSTOP WHICH DOES NOT ACHIEVE RELIABLE, AUTOMATIC RESET IS NOT CONFIGURED CORRECTLY AND MUST NOT BE COMMISSIONED FOR USE.



PROPER RESET OF THE ZIPSTOP AND EAD MUST BE INSPECTED PRIOR TO EVERY DESCENT. DO NOT INITIATE SUBSEQUENT RIDER DESCENT UNTIL BRAKING ZONE IS CLEAR, BRAKING SYSTEM PROPERLY RESET, AND INSPECTED.



USE OF SUPPLEMENTAL SYSTEMS WHICH ADD RESISTANCE TO THE BRAKING FUNCTION, SUCH AS COUNTERWEIGHTS, OR CLOTHESLINES, ETC. ARE PROHIBITED.



NEVER ATTACH AN EAD OR OTHER COMPONENTS TO THE ZIPSTOP BRAKE TROLLEY: IN ORDER TO MAINTAIN INDEPENDENCE BETWEEN THE PRIMARY BRAKING SYSTEMS AND EAD, THE ZIPSTOP CANNOT BE TETHERED TO OR BE USED TO RESET THE EAD OR OTHER COMPONENTS.

COMMISSIONING TESTING THE BRAKING SYSTEM

The correct operation of any zip line braking system depends upon whether participants arrive at the braking area within the allowable arrival velocity of the primary brake and EAD at all times. The responsible parties must ensure that every rider arrives at the terminal braking area within the maximum arrival speed in any condition of both brakes without exception. The maximum rider arrival speed of the zip line is limited by the primary brake or EAD with the **lower** maximum arrival speed. Because so many variables exist, particularly wind speed and direction, predicting arrival speed is complicated and variable; refer to Section: **Factors Affecting the Braking System Performance** for additional information. There is no way to ensure arrival speeds remain within braking system limits in all conditions without proper and complete testing. Testing of the zip line primary brake and emergency arrest device (EAD) is a required and critical step which must be completed as part of commissioning any zip line utilizing a zipSTOP. Testing is required to verify proper braking system function, establish baseline performance for comparison with theoretical results and future testing, verify the braking system is fail-safe, and establish the zip line operational envelope including a correlation between rider weight, arrival speed and other variables. Before commissioning a zip line, the Responsible Party MUST proof load test two critical systems: the primary brake and EAD. This section provides a framework for how testing must be conducted.



TESTING THE BRAKING SYSTEM IN ACCORDANCE WITH THIS MANUAL PRIOR TO ANY LIVE RIDER DESCENTS IS REQUIRED



THE TESTING PROCEDURES DESCRIBED BELOW ASSUME A ZIPSTOP IS USED FOR THE PRIMARY BRAKE WITH A NON-ZIPSTOP EAD. THE RESPONSIBLE PARTY SHALL MODIFY THE PROCEDURES AS REQUIRED FOR ALTERNATE BRAKING SYSTEM CONFIGURATIONS.



THE MAXIMUM ARRIVAL SPEED MUST NEVER BE EXCEEDED FOR THE PRIMARY BRAKING SYSTEM AND EAD IN ANY CONDITION.



ALL TESTING AND BRAKING SYSTEM PERFORMANCE MUST BE DOCUMENTED AND COMPLY WITH ASTM F2959 AND OTHER REQUIREMENTS IN ACCORDANCE WITH THE AUTHORITY HAVING JURISDICTION.

Testing the Braking System

- **Test weights:** Initial testing must be conducted using low-profile weights (i.e. plate weights). While a body profile might be more representative of riders on a zip line, higher-profile test loads cannot “canon-ball” as do live riders who want to go faster. If the operation permits prone rider orientation (head first / superman), test weights must have equal or lessor profile than that of a prone rider.
- **Test with a range of loads:** While it is critical testing includes the maximum allowable user weight, testing must be completed across the entire range of rider weights so that performance with all users is evaluated. Test weights shall gradually be increased so that the braking system limits are not inadvertently exceeded. Typically, heavier test weights have a higher arrival speed.
- **When to test:** Many variables affect speed but tailwind typically causes the greatest increase in arrival speed. It is impractical to expect maximum tailwind conditions during commissioning testing but testing with a head wind will yield low arrival speeds. Testing should begin during “neutral” conditions when wind is at a minimum and later account for wind-related and other effects, refer to Section: **Arrival Speed Correlation Testing**.

- **Test with broken-in trolleys and the fastest components / configurations:** Testing with new trolleys may result in slow arrival speeds. Because broken-in trolleys may travel faster than new ones, test with trolleys that represent the lowest rolling resistance and highest arrival speeds. If different types of trolleys, components / configurations, etc. are allowed, test using the fastest combination. To determine the fastest trolleys and components, perform repeated load descent tests with different combinations and use the one with the highest arrival speed. If the number of trolleys in the fleet is large, repeat testing with a large enough sample size to be confident the fastest components are selected.
- **Test Procedure:** Both the primary braking system and EAD must be tested and evaluated prior to ride commissioning. The following framework outlines the minimum testing requirements.

Test Procedure

Every descent shall be made from the launch platform, launching identically to a rider during normal operations. Arrival speeds must be measured with a radar gun from the landing zone. GPS equipment such as phones, handheld devices, etc. are not capable of accurately measuring arrival speed. Arrival speed is the speed at the moment of impact with the brake trolley. Prior to each descent, wind speed and direction shall be measured with an anemometer and documented. If different at the launch and arrival areas, record both.

Proof Load Testing the Primary Braking System

Initial weight testing provides a repeatable and safe method of verifying the braking system function. Test weight arrival speeds establish baseline performance for comparison with theoretical results, future testing and provide an indication of rider arrival speeds. While test weights typically arrive faster than riders of equivalent weight due to a lower profile, riders are more susceptible to increased or decreased arrival speeds due to wind. These results help the Responsible Party ensure proper braking performance of riders while gradually changing operational conditions which increase arrival speed. This information can be used to determine the operational envelope, refer to Section: **Arrival Speed Correlation Testing**. Test weight arrival speeds shall be sufficiently lower than the braking system maximum to ensure a factor of safety and operational margin in variable conditions and wind.



PROOF LOAD TESTING THE PRIMARY BRAKING SYSTEM MUST BE CONDUCTED WITH THE EAD PRESENT.



THE RESPONSIBLE PARTY MUST HEED THE FOLLOWING PRECAUTIONS DURING TESTING:

- If the arrival speed gets close to the maximum arrival speed, do not increase weights and stop testing. This indicates that the arrival speed or weight will need to be reduced, braking system and/or zip line modified. Refer to Section: **Interpreting Results**.
- If the braking distance gets close to the maximum allowable distance, stop testing and increase the redirection distance. If the redirection distance cannot be increased, the arrival speed or weight will need to be limited or braking system modified. Refer to Section: **Interpreting Results**.
- Any modifications to the braking system, including moving the redirection point, will result in changes to the arrival speed; testing must be repeated as required.
- Ensure operation does not occur below the BDmin line and is carefully evaluated within the grey area. Both regions are specified on the braking distance charts, Section: **Calculating zipSTOP Braking Distances / Braking Distance Charts**.

At minimum, conduct the following load tests and document results.

- 3 descents at the minimum weight
- 3 descents at ½ maximum weight
- 3 descents at expected average rider weight
- 3 descents at maximum weight

Results must include at least measured arrival speed, wind speed, and wind direction, refer to Table 5: zipSTOP Braking Performance Log for a sample documentation log. The following criteria must also be evaluated and shown to satisfy requirements:

- Proper braking system function including reliable automatic reset
- Braking distance and rider recovery zone less than maximum webbing extension
- g-Load/Rider swing up
- Undesired contact with the EAD or other components/structures

The Responsible Party shall complete a comparison between proof load testing results and the theoretical analysis performed by the zip line designer. This comparison may provide confidence in the ability to predict zip line performance / arrival speed. Strong correlation does not necessarily eliminate the requirements for correlation testing but poor correlation might indicate the need for additional testing.

Proof Load Testing the Emergency Arrest Device

Proof load testing the EAD must be conducted if it is not certified by the EAD manufacturer in accordance with ASTM F2959 or other requirements in accordance with the Authority Having Jurisdiction. If certified by the manufacturer, documentation stating its operational range including allowable rider weight and speed range must be supplied and retained with the commissioning report. Testing may be required to determine EAD arrival speed. If a zipSTOP is used within the EAD, proof load testing must be conducted.

The purpose of testing the EAD is to verify the braking performance, ability to safely arrest a rider, and create a fail-safe system. To test the emergency brake, disconnect the primary brake, ensure testing will not damage any components but will remain as it would be during normal operation, and perform weight tests. If a zip-STOP is being used as the primary brake, disconnect the redirection rope from the brake trolley and secure the rope out of the way to avoid possible entanglement. Ensure compatibility between the primary brake trolley and EAD.



TESTING MAY BE REQUIRED TO DETERMINE EAD ARRIVAL SPEED. EAD ARRIVAL SPEED MAY BE HIGHER THAN THAT OF THE PRIMARY BRAKE DUE TO LOCATION, ESPECIALLY FOR POSITIVE ZIP LINE SLOPES.



THE MAXIMUM ARRIVAL SPEED MUST NEVER BE EXCEEDED FOR THE PRIMARY BRAKING SYSTEM AND EAD IN ANY CONDITION.



LIVE RIDERS SHALL NEVER DESCEND A ZIP LINE WITHOUT REDUNDANCY OR A FAIL-SAFE BRAKING SYSTEM. NEVER PERFORM MANNED TESTING OF THE EAD WITHOUT A SUITABLE REDUNDANCY TO THE EAD OR OTHER FAIL SAFE COUNTERMEASURES.

With the EAD positioned as it would be during normal operations and the primary brake disconnected, perform the following:

- 3 descents at the minimum weight
- 3 descents at ½ maximum weight
- 3 descents at expected average weight
- 3 descents at maximum weight

The same criteria shall be evaluated for EAD performance as was evaluated for the primary braking system including, but not limited to: proper function, EAD arrival speed, braking distance, g-load/rider swing up, undesired contact with components/structures, etc.

Arrival Speed Correlation Testing

After proof testing both the primary braking system and EAD has been completed, shown to be adequate and fail-safe, rider testing of the zip line may take place. All manned descents must have both the primary braking system and EAD in place. If any modifications are made to the braking system, proof testing must be repeated before live testing can resume. Initial testing shall occur under the same operational, environmental, etc. conditions as proof load testing during minimal wind with no variables present that would result in a higher arrival speed than the equivalent test weight; i.e. don't start live testing during strong tail winds that can reasonably be expected to result in increased arrival speeds.

The goal of manned rider testing is to develop a correlation between arrival speed and all variables affecting arrival speed, predominately rider position and wind speed / direction. This correlation becomes part of the operational envelope and is used to determine when to cease operations to prevent exceeding the maximum arrival speed. There are many variables which affect rider arrival speed, including, but not limited to wind speed/direction, rider position, rider weight, temperature, cable tension, etc. Wind typically affects rider speed more than a low profile test weight. For this reason, the heaviest riders may not arrive at the fastest speeds; often, the fastest arrival speeds are achieved by riders with an optimal weight to wind profile ratio.

Due to the unique nature of individual zip lines and the variables that affect arrival speed *it is up to the Responsible Party to determine an adequate test schedule to determine an operational envelope which accounts for all operational variables*. Because it is impractical to expect the maximum allowable tail winds, etc. to be present during testing, the Responsible Party will need to understand the consequences of operating during such conditions then establish operational parameters, procedures and/or ongoing monitoring to ensure riders will NEVER exceed the allowable arrival speed in any condition. Supplemental performance monitoring of arrival speed, etc. may be required and shall be completed by the owner/operator during operation. This information is used to determine all unknowns and fully define the operational envelope. This must occur for all operating conditions that were not tested during commissioning and/or where performance is too variable to determine stoppage criteria. *The Responsible Party must provide all test data and detailed instructions to the owner/operators regarding how to properly perform this supplemental monitoring, determine operational envelope limits and ensure the maximum arrival speed is never exceeded in any condition*. Test results and zip line braking performance must be documented in the commissioning report and retained by the owner/operator.



THE MAXIMUM ARRIVAL SPEED MUST NEVER BE EXCEEDED FOR THE PRIMARY BRAKING SYSTEM AND EAD IN ANY CONDITION.



THE COMMISSIONING DOCUMENT MUST CONTAIN THE ORIGINAL TEST RESULTS / BRAKING SYSTEM PERFORMANCE AND A COPY BE RETAINED BY OWNER/OPERATOR AND OTHER RESPONSIBLE PARTY. THE RESPONSIBLE PARTY MUST SHOW RESULTS MEET ALL REQUIREMENTS.

To conduct testing, change variables one at a time, progressing from the slowest configuration / variables to faster ones. Stop testing if arrival speeds get close to the maximum allowable. Conduct testing following the same procedures as normal operations.

Testing must follow these guidelines:

- Initial testing shall start during neutral conditions with minimal wind speed
- Change/increase variables one at a time from slowest to faster ones
 - With minimal wind - increase rider weight
 - With minimal wind - vary rider position then increase rider weight
 - Allow increased tailwind while increasing weight and changing rider position
 - Increase other variables with the same methodology
- Evaluate performance and record results after each descent, ensuring performance remains within limits

Monitoring results during normal operations shall include measured arrival speed, wind speed, and wind direction, refer to Table 5: zipSTOP Braking Performance Log for a sample documentation log. This data and any modifications to the operational envelope must be added to the commissioning report on an ongoing basis.

Interpreting Results

One of the major goals of testing is to determine the operational envelope, the parameters that would result in exceeding the maximum arrival speed or other conditions, and establish limits and procedures to prevent this from happening. If, at any point during testing, arrival speeds continually increase and get close to the maximum allowable arrival speed, those testing conditions are the operational envelope limits. For example, if increasing rider weights correspond to increasing arrival speeds that gets close to the maximum arrival speed of either the primary brake or EAD, those tested conditions (weight, wind speed / direction, rider position, etc.) are the limits of operation; exceeding these conditions (i.e. a heavier rider or stronger wind) cannot be allowed. Care must be taken if lighter weight riders arrive faster than heavier weight riders or other scenarios exist that don't follow the correlation of increasing speeds.

If operation of the zip line will exceed limits within desired operational parameters, for example if the braking system maximum arrival speed is reached at a, undesirable light weight, there are several options which may be employed:

- Contact the zip line designer and compare test results with design estimations to determine if / why arrival speeds are higher than anticipated.
- Determine if the zipSTOP model / configuration used is appropriate. Use a model / configuration with a higher maximum arrival speed if available. Refer to Section: **Determining Device Model, Reduction Ratio and Configuration** for additional information.
- Reduce maximum rider weight. This may be a good option if changing limits aren't too restrictive for operations.
- Change allowable rider position / orientation. Increasing rider profile area may reduce arrival speed, however, increased area may increase arrival speed during tailwinds.
- Implement speed limiting components such as resistance trolleys to reduce arrival speed.
- Use a different braking system, zipSTOP may not be suitable for all zip line designs.

Annual and Modification Test Requirements: Re-Commissioning

The proper operation of any zip line depends upon whether participants arrive at the braking area within the allowable arrival speed of the primary braking system and EAD. Upon original commissioning of your zip lines, the Responsible Parties will have designed, tested and determined procedures to ensure operation with the operational envelope.

Because many elements can change over time, it is a requirement that periodic testing be performed of the zip lines and braking system to verify original performance. Testing shall be conducted annually and upon any modification that may affect zip line or braking system performance. Periodic load testing and monitoring is the only way to ensure that arrival speeds remain as designed and stay within established limits in any condition. The Responsible Party must include instructions regarding testing intervals, requirements and procedure within the zip line operational / maintenance documents.



RE-COMMISSIONING TESTING IS REQUIRED ANNUALLY AND UPON ANY MODIFICATIONS THAT MAY AFFECT ZIP LINE OR BRAKING SYSTEM PERFORMANCE.

Proof load testing of the primary braking system must be conducted, at minimum, under the following circumstances and as determined by the Responsible Party:

- Annually, upon reinstallation of the zipSTOP after recertification
- Upon any significant modification to the zip line including adjusting tension outside original tested parameters or cable replacement.
- Upon any significant change to components used: trolleys, harnesses, tether length, etc.
- Upon any significant change to allowable operational parameters including weight, rider position/orientation, etc.

The recommissioning testing procedure and evaluation criteria shall be determined by the Responsible Party and be adequate to verify original commissioning test results and operational envelope. In addition to testing, results shall be compared with the baseline established during commissioning and any previous re-commissioning results. Significant differences must be evaluated by the responsible parties and shown to be acceptable.



ALL RE-COMMISSIONING TEST RESULTS MUST BE ADDED TO THE COMMISSIONING DOCUMENT AND RETAINED FOR THE LIFETIME OF THE ZIP LINE.

The chart below is an example of data to be collected.

Line #: _____

Device Model: _____

Device S/N: _____

Trial	Test Weight	Arrival Speed	Braking Distance	Wind Direction	Wind Speed	Temperature	Notes
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

zipSTOP Braking Performance Log

Adjusting the Braking Performance

Once testing is underway, results shall be compared to the calculated estimations. Gross discrepancies such as excessively short braking distance may indicate a problem or incompatibility and should be investigated. Small deviations are expected. Adjusting the braking system will help to optimize the braking distance and landing area relative to the arrival platform / dismount locations and to ensure smooth, comfortable braking of the rider. Most of the necessary adjustments can be completed by moving the redirection point forward or backward. Refer to the following chart to determine what adjustments can be made.

How to	Do this
Reduce rider swing up / g load	Ensure operation above BDmin Line
	Check sag in reduction rope, initial webbing extension
	Reduce arrival speed
	Increase rider (min) weight
	Increase pivot height
	Change to ZS model with higher max arrival speed
	Add rider orientation control
Move Landing Zone Forward (Farther from Zip Line Termination) / Reduce Braking Distance	Move redirection point forward
	Decrease arrival speed
	Decrease pivot height
	Reduce rider (max) weight
Move Landing Zone Backward (Closer to Zip Line Termination) / Increase Braking Distance	Move redirection point backward
	Increase pivot height
	Increase rider (min) weight

Braking Performance Adjustments

Troubleshooting

Refer to the below table for troubleshooting items. Contact Head Rush Technologies for additional information. When requesting additional assistance, please have any relevant information available: device serial number, braking performance information (arrival speed, weight range, etc.), photos, video, etc.

Installation Troubleshooting Chart	
Problem	Cause/Solution
Sudden and Severe Webbing Wear	Webbing not routed straight out of device.
	Webbing has abraded on structure, cables, etc.
	Overspeed has occurred, internal device damage may exist. Damage will repeat on new webbing even at acceptable arrival speeds. Requires service by an authorized servicing agent.
Abrupt Braking / Rider Swing Up	Incompatible rider or brake trolley, hardware/components. Worn BumpStop pads.
	Pivot height too low
	Arrival speed too high
	Operating conditions near/below BD min line
	Excessive redirection rope sag
	Brake line not properly retracted
Device Fails to Retract	Components or rope jammed/tangled
	Redirection ropes, webbing not running free and clear
	Broken retraction spring, requires service by authorized servicing agent
	Reduced cycle life in retraction spring indicates repeated cycles at maximum line extension. More frequent service required.
Retraction is Unreliable	Incompatible components - check sheave diameters, all components, Redirection rope
	Ropes are tangled, rubbing on itself during retraction
	Webbing not coming straight out of device
	Poor redirection rope routing

Redirection Rope Sag	Webbing not fully retracted or system not properly reset.
	Rope may need traveler assembly or fixed support pulleys
	Rope may be too long or have stretches, remove slack from system
Arrival Speed Exceeds Device/Configuration Limits	Cease operations immediately. Devices subjected to overspeed require service by an authorized servicing agent. Contact designer/ installer.
Damage to Zip Line at Brake Trolley Reset Location	Use of incompatible rider trolleys
	Improper brake trolley / sheave size
	Use brake trolley stabilizer accessory

Braking Performance Troubleshooting

IMPROPER OPERATION



THE FOLLOWING SCENARIOS ARE NOT ALLOWABLE, MAY CAUSE DEVICE DAMAGE, AND CREATE A DANGEROUS SCENARIO WHICH COULD RESULT IN EQUIPMENT DAMAGE, SERIOUS INJURY OR DEATH.

- Arriving faster than the device maximum may cause the following:
 - Separation or damage of the webbing and/or redirection rope.
 - Internal device damage to the zipSTOP which is not inspectable. This damage will cause sudden and repeated webbing damage during normal operation. If this occurs, the zipSTOP will need to be sent to an Authorized Servicing Agent for inspection and repair.
 - Exceeding the maximum braking distance resulting in undesired contact with the EAD.
 - Overextension of the webbing causing an abrupt stop and damage to the webbing/device.
 - Excessive braking force and rider swing up.
- Arriving with a higher weight than the device maximum may cause the following:
 - Separation or damage of the webbing and/or redirection rope.
 - Internal damage to the zipSTOP which is not inspectable. This damage may and manifest as problems with webbing retraction, extension.
- Using multiple zipSTOP devices simultaneously (in parallel) may cause the following:
 - Abrupt braking and rider swing up.
 - Damage to the webbing, redirection rope and/or zipSTOP internal components.
- Braking more than one rider at a time may cause the following:
 - Separation or damage of the webbing and/or redirection rope.
 - Abrupt braking and rider swing up.
 - Damage to the internal retraction spring resulting in failure to retract / reset.
 - Internal damage to the zipSTOP which is not inspectable.

TERMINOLOGY

Arrival Speed – The speed at which a patron is traveling the moment the zipSTOP brake trolley is engaged. Arrival speed must always be lower than the device/configuration maximum. The maximum arrival speed must be accounted for in any operational condition.

Authority Having Jurisdiction – an organization, government entity or individual responsible for approving, regulating, or enforcing the requirements of a code, standard, regulation, etc.

Automatic Reset – zipSTOP fully retracts webbing and positions brake trolley at redirect point automatically. This function shall not be compromised by installation of ancillary systems (EAD, retrieval system, etc.)

BDMin Line – BDmin Line indicates the rate of deceleration that may be considered uncomfortable and result in sever rider swing up when stopping. It is not recommended to operate the zipSTOP with combinations of rider weights and arrival speeds that fall below the BDmin line.

Brake Reset – See automatic reset

Brake Trolley – Attaches to zip line and is connected to the zipSTOP webbing via redirection rope or tether when used with a Pivot Mount. The brake trolley acts as an impact surface for rider trolley and the interface to engage zipSTOP.

Brake Trolley Impact Stabilizer – Accessory with an additional 4th sheave assembly that can be added to any Head Rush Brake Trolley. The Brake Trolley Impact Stabilizer is recommended for slack or low tension zip lines and/or offset redirection points.

Braking Cycle – a single sequence of arresting a participant with a zipSTOP device, dismounting the participant and brake trolley automatically resetting to the reset position.

Braking Distance – Distance rider travels after engaging zipSTOP brake trolley until fully stopped.

Braking System – Combination of primary and EAD or emergency brakes and all associated components used to arrest riders at terminal end.

Actual braking distance – Field measured braking distance. Necessary to test, record and audit.

Calculated braking distance – Theoretical derived from calculations based on user input. Useful for initial zipSTOP setups but must be confirmed through testing.

Braking Extension – Length of webbing deployed from zipSTOP during braking cycle.

Buffer Zone – Distance between end of zipSTOP braking cycle and termination of zip line

bumpSTOP – Field replaceable wear component acting as a rubber impact surface on the Head Rush Brake Trolley.

Cable Clamp – Hardware used to terminate cables and attach hardware to cables. Must be installed and torqued to manufacturer’s requirements.

Catenary Curve – profile view of unweighted zip line determined by tension in line, the line’s weight and properties. Large component effecting rider acceleration, max speed, and arrival speed.

Competent Person – Person that has knowledge/training to work on a zip line. Typically operates under supervision of a qualified person.

Connector - A hardware component used to connect two or more things together. Commonly a quicklink / Maillon.

Designer – Qualified person responsible for the design of a course or component thereof.

EAD – Emergency Arrest Device, or Emergency Brake: An EAD is a suitably designed, engineered and tested independent secondary brake that result in a fail-safe condition in the event the primary brake does not perform as designed. An EAD is required by Head Rush Technologies whenever a zipSTOP is used as the primary brake. The EAD must automatically engage upon failure of the primary brake. An EAD cannot be dependent on a participant or guide to engage. EADs must meet the requirements of ASTM F2959 and other equirements in accordance with the Authority Having Jurisdiction.

Engineered System – Course or component thereof designed by a qualified person and installed and used for its designed purpose.

Fail-safe - The condition or characteristic in which a failure mode of the ride / device results in safe operation that does not cause serious injury to any participant.

Fixed Support pulley – Pulley fixed to accessory cable used to support long lengths of redirection line.

Gantry – Overhead structure that’s suitably rated for use as a secondary anchor point or as a support for an overhead cable.

Impact Braking – A type of zip line braking where the rider trolley contacts the brake trolley.

Installer – Qualified / Competent person(s) who performs the installation of the zip line, components, etc.

Maximum Extension – The maximum amount of webbing that can be pulled out of the device.

Negative Line slope – Unweighted zip line profile/angle that slopes uphill.

Neutral Line slope – Unweighted zip line profile with neither downhill or uphill profile/angle.

Operating Envelope – the documented set of limits and conditions which zip line operations must stay within to ensure proper operation of the zip line and braking systems. The operating envelope must include criteria to prevent an overspeed. An operating envelope may include such criteria as maximum allowable wind velocity / direction, minimum/maximum rider weight, rider position, etc.

Operator – Person responsible for operation of zipSTOP.

Overhead / Accessory Cable – Line running generally above and parallel with zip line used to mount redirection points, traveler assemblies, pivot mounts, etc. The overhead cable may traverse the entire length of the zip line or just over the braking area (at least from the terminal structure to the redirection point).

Overload – Engaging zipSTOP with rider above max weight specified in manual. Unit must be removed from service immediately and sent in for recertification due to potential damage to internal parts.

Overspeed – Engaging zipSTOP above max speed specified in manual for given install. Unit must be removed from service immediately and sent in for recertification due to potential damage to internal parts.

Owner – Party with ultimate responsibility and oversight.

Participant – A rider, guide, observer or any person involved with operation.

Patron – Guest or client of zip line course

Pivot Height – In a 1:1 or 2:1 installation, the pivot height is the vertical distance between the redirection pulley and zip line while both are unloaded. For pivot mount installs the pivot height is the vertical distance between the zipSTOP nozzle and unloaded zip line. Minimum pivot height for both installation types is 1m (3.3ft).

Pivot Mount – Accessory assembly that eliminates the need for a redirection system and supersedes the mounting base. May only be used with zipSTOP and zipSTOP IR devices.

Pivot Point – When using a pivot mount the location the mount is secured to the overhead line or structure.

Positive Line slope – Unweighted zip line profile/angle that slopes downhill.

Primary Anchor – Main attachment point/structure for zipSTOP mounting base. Most commonly, but not limited to, a post, beam, tree or wall.

Primary Brake – Principle brake in a zip line braking system. Engaged in normal operation in order to arrest participant.

Qualified Person – Person recognized as an expert or credentialed by third party in the field of work.

RattleSTOP – Rubber inserts used to ensure secure fit and minimize vibration between the zipSTOP Device and mounting base.

Recertification – Mandatory annual servicing of zipSTOP device by authorized service center. During recertification a device is disassembled, cleaned, inspected and tested.

Redirection point – In a 1:1 or 2:1 configuration, assembly/location that contains the redirection pulley and necessary hardware to attach the redirection pulley to a cable or structure. The redirection rope changes direction at the redirection point.

Redirection pulley – Pulley that meets the requirements stated in this manual that is fixed to a cable or structure and supports or directs redirection rope/line.

Redirection Rope/Line – Textile cordage that meets the requirements stated in this manual and attaches the terminal end of the zipSTOP webbing to the brake trolley through the redirection/reduction pulley.

Reduction pulley – Lightweight pulley that meets the requirements stated in this manual that is used within a 2:1 installation. The reduction pulley attaches to the terminal end of the zipSTOP webbing or tether with a suitable connector.

Reduction ratio – External arrangement of redirection line and pulleys used to adjust zipSTOP braking by modifying brake rotor speed. Reduction ratios may either be 1:1 or 2:1 depending on zipSTOP device model. In a 2:1 reduction, the brake trolley travels twice as fast and as far as the webbing assembly.

Reset position – The location on the zip line cable that the brake trolley returns to when brake system reset functions properly. For an overhead cable, this is immediately below the redirection point.

Responsible Parties – Person(s) accountable for certain aspects of installation, inspection, maintenance, operation, etc. The Responsible Parties may include designer, installer, owner, operator, inspector, etc.

Retraction Spring – internal component of the zipSTOP responsible for retracting webbing and resetting brake trolley to the reset position. The braking function operates independently of the retraction spring.

Rider – Any person descending on a zip line

Rider Trolley – Zip line trolley connected to rider to traverse zip line. Different trolleys and overall condition can greatly affect arrival speed.

Rider Weight – The combined weight of rider and all attached equipment.

Secondary Anchor Point – In a 1:1 or 2:1 configuration, the attachment point/structure for the redirection point. This is commonly an overhead cable.

Serious Injury – The threshold for a serious injury includes any of the following: fractures, amputations / dismemberment, permanent loss of the use of a body organ / member / function / system, injury likely to lead to permanent loss or reduction of sight, any crush injury to the head or torso causing damage to the brain or internal organs, serious burns, any scalping, any loss of consciousness caused by head injury or asphyxia, significant disfigurement, loss of a fetus, or other significant injury / illness that requires immediate admission and overnight hospitalization and observation by a licensed healthcare professional.

Serious injury is also commonly determined by the Authority Having Jurisdiction; the more conservative definition applies.

Definition from EN15567 and ASTM F2959

Terminal End – Landing/arrival side of zip line.

Terminal Platform – Structure at the terminal end where participants dismount zip line.

Traveler Assembly – Components generally consisting of a pulley on the overhead cable and short tether attached to the terminal end connector of the zipSTOP webbing. Used to support the weight of the zipSTOP webbing, redirection rope, connector and reduction pulley as it extends and retracts from the device.

Webbing (Assembly) – Flat textile component contained within the zipSTOP. A braking force is applied to the webbing when it's extracted from the device.

zipSTOP Mounting Base – Mount used to connect the zipSTOP to the primary anchor when installed in a 1:1 or 2:1 configuration

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ASTM F2959 AND F1193 CERTIFICATION

This page serves as the ASTM F2959 and F1193 compliance certificate for the zipSTOP Zip Line Brake attached. This zipSTOP device is in compliance with ASTM Practice F2959 and F1193. This device has passed all quality assurance and manufacturing processes for components, subassemblies and final product performance in accordance with Head Rush Technologies' quality assurance program.



REGISTER YOUR DEVICE

Get automatic updates on recertification and product information – visit headrushtech.com/register

ANNUAL RECERTIFICATION IS REQUIRED

Please keep the shipping box for your device. For instructions on annual recertification, visit headrushtech.com/recertification

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