Rescue Rope Performance Requirements

Impact Forces, Elongation, and Life Safety Rope

The elongation of a life safety rope relates directly to the impact forces encountered when the rope stops a fall. The important question is “how much elongation” is right for any particular application. A few years ago it was a simple choice. Sport climbing ropes had too much stretch, and “static” kernmantle caving ropes had enough stretch to provide some energy absorption, but not enough to make them inefficient in systems.

In 1998, the Cordage Institute published standard (CI-1801) that defined a “static” rope as having 1% to 6% elongation at 10% of the rope’s minimum breaking strength. A “low-stretch” rope would have 6% to 10% elongation at the rope’s minimum breaking strength. NFPA Standard 1983 on Life Safety Rope sets the standard for elongation between 1% and 10% at a load equal to 10% of the rope’s minimum breaking strength.

Elongation is really just another way of describing how much a rope will stretch when it is loaded suddenly. This stretching, or elongation, reduces the impact force. The greater the elongation, the less force felt by the system. A good example would be a bungee jumper taking a tremendous fall (jump) and stopping very comfortably. The critical factor, of course, is having plenty of distance in which to stop.

Unfortunately, in a rappel or stretcher system, rope with high elongation is a problem. When a person on rappel or tending a stretcher starts down, the rope stretches as the load increases. This means there is more rope between the anchor and the rescuer, causing an uncontrolled downward movement and introducing a risk of the rescuer hitting a ledge or the ground. With high elongation rope in a raising system, the haul team has to pull the stretch out of the rope before moving the load, thus reducing the team’s efficiency. For these operations, an ideal rope would have very low elongation.

It might seem that rope with high elongation would be appropriate as a belay line. After all, a belay line catching a fall is a dynamic event, and the impact forces throughout the system are greater than the static load. A high elongation rope would absorb energy and minimize the impact. But, as described above, this requires a safe distance in which to stop. Unfortunately, in rescue there are too many ledges, edges, and other hard things that could be more damaging to the rescuer and patient than having the rope stopping them quickly.

Determining How Much Elongation is Right for You

Here is how we suggest you decide “how much elongation” is right for you. First, determine a maximum acceptable impact force that a stretcher system should be able to tolerate without causing harm to the people or failure of the system. The value that has been suggested by many, and is being considered for several standards is 15 kN. This number was proposed many years ago by the British Columbia Council on Technical Rescue for their Belay Competence Drop Test standard.

Next, determine the desired stopping distance in your belay system. This requires looking at both elongation in the rope and the type of belay device being used. The BCCTR standard recommends a maximum stopping distance of 1 meter. When you have determined your requirements for impact force and stopping distance, test your belay system to see if it meets your needs. View the system as a whole, including rope, belay device, operator, and anticipated loads. Different belay systems can impart different impact forces on the system and should be tested as a unit. ASTM F2436-05 Standard Test Method for Measuring the Performance of Synthetic Rope Rescue Belay Systems and Equipment provides a test method for comparing one system to another. The best belay system will be one that arrests a fall in the shortest distance and stays below the maximum acceptable force on the system’s components.

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NFPA 1983 (2006) Rope Performance Requirements

Light-Use

Minimum 3 sigma breaking strength (3s MBS) of not less than 20 kN (4,496 lbf.)
Minimum elongation of not less than 1% at 10% of the breaking strength
Maximum elongation of not more than 10% at 10% of the breaking strength
Minimum diameter of 9.5 mm (3/8-inch)
Maximum diameter of 12.5 mm (1/2-inch)

General-Use

Minimum 3 sigma breaking strength (3s MBS) of not less than 40 kN (8,992 lbf)
Minimum elongation of not less than 1% at 10% of the breaking strength
Maximum elongation of not more than 10% at 10% of the breaking strength
Minimum diameter of 11 mm (7/16-inch)
Maximum diameter of 16 mm (5/8-inch)

Note: the NFPA convention is to round off to the nearest .5 mm (1/64-inch).

New for 2006 is the lower diameter allowed for General-Use life safety ropes. Today, the fiber technology does not exist to make a 7/16-inch General-Use life safety rope, but the committee wanted to keep the door open for such a light weight, high-strength rope.

Also new for the 2006 edition is the requirement that the label provide the user with information on the elongation at specified working loads. This will greatly help the user determine which product best meets his requirements.

Elongation at 1.35 kN (300 lbf.)
Elongation at 2.7 kN (600 lbf.)
Elongation at 4.4 kN (1,000 lbf.)

NFPA 1983 (2006) Throwline Performance Requirements

Minimum breaking strength of not less than 13 kN (2,923 lbf.)
Minimum diameter of 7 mm (19/64-inch)
Maximum diameter of 9.5 mm (3/8-inch)

After a 24 hour immersion in water, the entire length of the throwline must float to the surface within one minute.