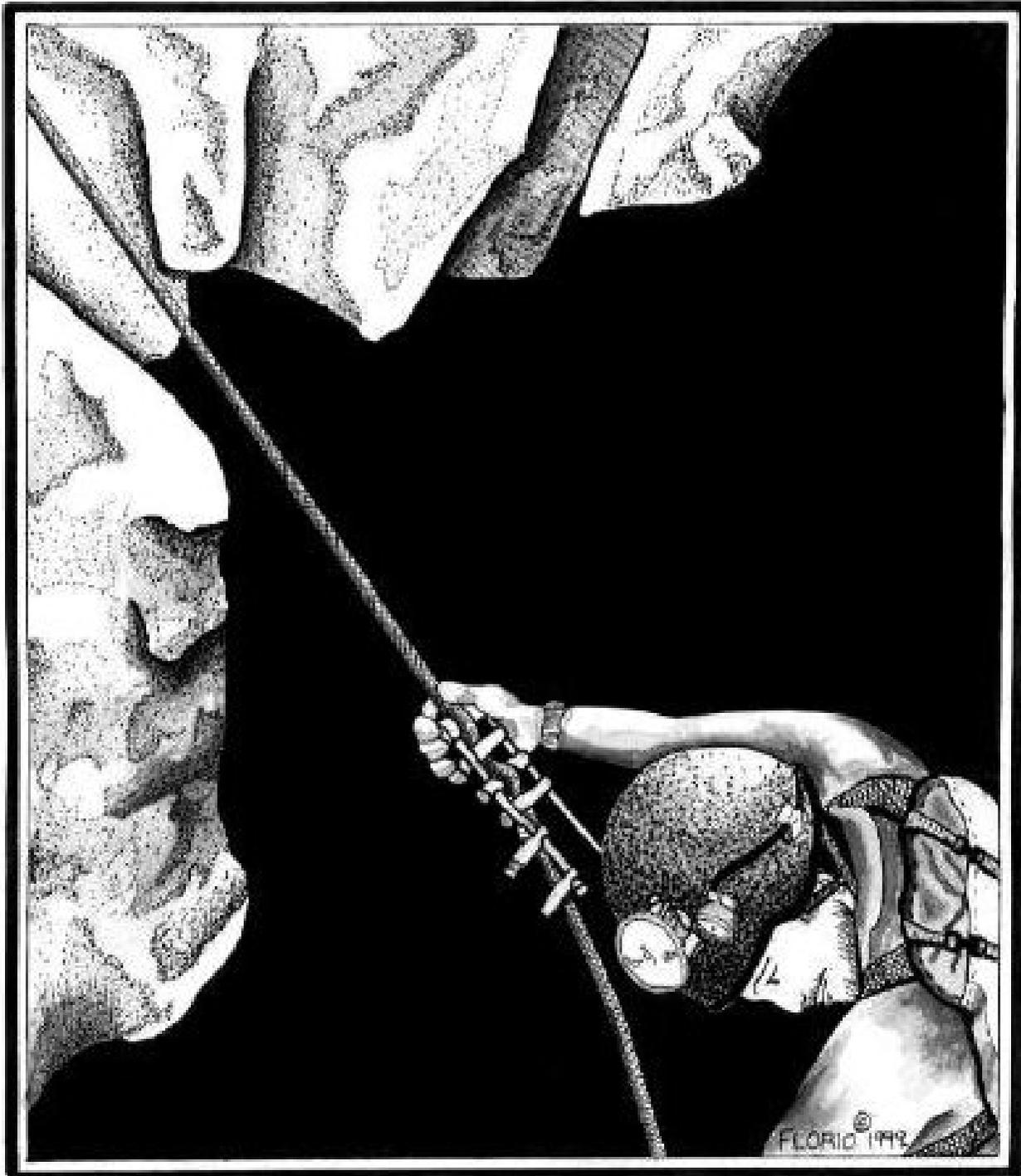


# *Nylon Highway* Issue #45

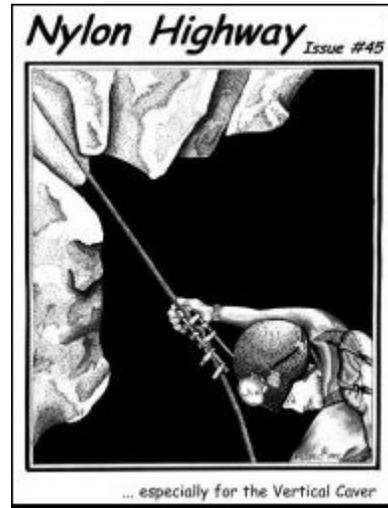


... especially for the Vertical Cover



**#45**

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# **Hanging After a Fall: An Extremely Urgent Rescue**

*By Maurice a AMPHOUX*

At first, nobody can believe that it can be deadly dangerous to remain hanging passively in a well-designed harness. It is, however, a proven truth, albeit generally not known, and it is to remind and stress the consequences of this fact that I want to mention it today.

I shall first mention why the habitual users of this equipment cannot understand their danger. Then I shall mention why some disbelieving people (and I was one of them) have been led to change their minds. Lastly, I shall emphasize the resulting consequences, in my opinion, of which I would like to convince you. Let us first see why habitual users of such equipment find it hard to admit that it can be dangerous.

We have all seen pruners or linesmen working installed on supporting systems. They often have feet against the tree trunk or the electric pole on which they are working and are therefore only partially supported on their bottoms. Their holding tether [or strap] is at an angle and helps support on their feet. But it is quite possible, even if it is less convenient; that the tether is vertical and that all the body weight is supported by the holding system. This is not convenient for working, owing to the lack of a fulcrum and of a horizontal component. It is the equivalent of working in a state of weightlessness. But it is perfectly bearable without malaise, for several dozen minutes if necessary.

In building and public works, it is also a common situation in order to carry out brief or urgent repairs on a sloping roof, even on a gable or a façade. In France this was still recently the usual technique to install or repair the gutter or down pipes. The worker used a knotted rope on which he was moving a small plank used as a seat. This looked like a swing and was called the old name of "working the 'escarpolette' [old French word for swing] way". It is no longer authorized unless completed with anti-fall harness and a vertical supplementary support. But this is still a perfectly tolerated hanging working way. Cavers readily use light pelvic harnesses with forward fastening which facilitate their progress along the ropes. Their explorations often require lots of materials which have to be transported then brought back up after use. This requires often working dangling in space for relaying and that can last several hours. With a well thought out and well-adjusted harness, it does not create any notable lack of comfort. In mountain climbing this type of situation is less common but can occur, for example when anchoring pitons in a climbing path. Similar techniques are now also sometimes used in the upkeep of some unusual modern architectural constructions, as for example, the cleaning of the well known glass pyramid of The Louvre in Paris. And as far as parachutists are concerned, it is never coming down held by their harnesses, which causes any difficulty.

Therefore none of these sportsmen or these professionals, none of those who design and supply this equipment would have dreamed of incriminating it.

With the team I was supervising some years ago, we got interested in the system for

stopping falls with the building workers. We rapidly came to the conclusion that the traditional belts were incompatible with any fall and even more so with maintaining the holding, be it only for the time to wait for help. And we could not exclude falls of the order of four meters. This is the range of fall of a worker at the highest sold cramping point. The fall being able to happen as well through toppling head first as feet first, the only reasonable solution for any fall stopping system was the complete anti-fall harness as defined in the standard EN361.

But still it was necessary to ensure that the hanging support did not cause any problem after the fall. None of the successive equipment elaborated and previously tried seemed bearable for long, including the pelvic harness which imposes a considerable effort to remain in a sitting position with the help of the arms. And then it was necessary to foresee the case, especially unfavorable but still possible though rare, of a fall caused by an impact resulting in loss of consciousness, or a fall resulting in an impact against the substructures with the same consequences: impossibility to make help easier and prolonged maintaining in passive suspension and total muscular relaxation. But with the knowledge of the experiments mentioned earlier, we anticipated that a complete harness would be comfortable and we tried, without any special precaution, a well adapted parachute harness ... until loss of consciousness of the subject. Surprised, but in no way worried by this transitory and unexplained malaise, we started again with other subjects and other harnesses, under telecardiographic control. The result repeated itself for each one with sudden modification of the cardiac rhythm without warning symptoms with delays varying from two to twelve minutes. The national research institute on security confirmed these results. Because of lack of means of resuscitation, we did not dare continue these trials but we did publish our data.

These data alerted two quite different teams. One was Jim Brinkley's who called upon the remarkable installations of the physiology laboratory of the US Air Force to contribute in sufficient safety conditions and which confirmed our results. The other one was that of the French Federation of Speleology. In spite of their initial absolute skepticism, they carried out several trial campaigns, including in a hospital service, of cardiac resuscitation to try and find an explanation and some preventative means. They first showed that high quality sports people, in perfect physical condition, and capable of excellent muscular relaxation, lost consciousness in a few minutes, always without warning signs. Some trials in various hanging positions have shown that the low position of the lower limbs was a determining factor. They also collected some stories of subjects who died while hanging and which could be explained as well by this type of fainting as by exhaustion or exposure.

In fact several hypotheses have been raised to explain the observed troubles. It was possible to invoke the inevitable compression of the tops of the thighs on most of the harnesses tried. Even if that compression was light, it was possible that there was a disturbance with return [blood] circulation and cardiac depression caused by the accumulation of the waste products. But the troubles occurred just as much with certain harness models in which the buttock straps are kept in place by straps which did not compress at this level. This type of compression is, however, to be feared even with a well-adapted harness, if it shifts during the fall. A second hypothesis has been raised during some trials where the hanging straps were in lateral contact with the neck and could have stimulated the carotid baroreceptors. But this arrangement is unusual.

The most probable hypothesis therefore is that absence of muscular contractions more than the compression's lead to an important blood stasia at the level of the lower limbs. Besides there exists constantly a certain local cyanosis. The lowering of the amount of circulating blood may determine a certain degree of cerebral anoxia aggravated by the trouble of the cardiac rhythm which stems from the same mechanisms. This hypothesis has been largely confirmed by basic knowledge in resuscitation anesthesia. Surgical operations under general anesthesia are only carried out in low legs position for certain special types, more particularly the intra-cranial operations. Anesthetists know that the moment when a patient is brought back to the horizontal position is often delicate and must be especially watched, often necessitating hyper-oxygenation and cardiac support. Thus the mortal risk of keeping an unconscious subject suspended in his harness is confirmed and explained.

The lessons to be learned from these observations follow:

The first is that this risk is difficult to believe. None of those we have met and who are used to this equipment could believe from the start that, in some particular circumstances it could become deadly dangerous. Indeed we would not advise anybody to repeat the experiment. Some years ago, the demonstrator of a major French manufacturer was in the habit of letting himself fall 4 meters with harness and shock absorber in all safety conditions; he possibly holds the record of several thousand falls without an accident. To convince him I had to let him hang in his workshop while we continued to exchange jokes until I had to release him urgently. I would not dare to do it again under any circumstances. It is necessary to accept the common evidence of our four teams, so different from each other.

Another difficulty stems from the fact that it is an uncommon risk. It is difficult to estimate the probability, at least for workers. Falls without harnesses, with their deadly consequences, do not exceed a few dozen per year in our country. Falls with a stopping system are probably of the same order, but not counted because generally without consequences. Falls with loss of consciousness are probably rarer still. But there is absolutely no reason why the few deaths that might stem from them be attributed to their real cause. The lack of knowledge of this type of accident has therefore every chance of continuing unless the necessary publicity is given.

As regards mountain climbing, there is cause to think that it is similar. Certainly falling is part of the game and is less unusual than a work accident. But it is often restrained, anticipated for a few seconds and happens in front of experienced witnesses. The probability of remaining in a state of prolonged suspension leading to loss of consciousness is small and, eventually, will find in case of death an obvious explanation between the triggering trauma and cold [or 'exposure'] without thinking of an enquiry which would have only scientific interest. A similar accident while parachuting or paragliding would have no more reason to be investigated.

The case of caving [speleology] is slightly different, to the extent where staying in suspension is a frequent occurrence, but the falling is unusual. On the other hand it seems that the often very physically demanding conditions in the course of several days could lead to an exhausted state rendering the climb back up dangerous. In any case the risk did not seem negligible to the French Federation of Speleology which has given precise

instruction that any subject losing consciousness while in suspension be very urgently rescued, un-hung or toppled over head down and given mouth to mouth resuscitation.

On second thoughts, this should become evident. No first aid worker, nobody, even with little knowledge would imagine leaving a person in a fainting fit in an armchair. He or she would immediately be put in a lying position which would often be sufficient to bring back consciousness. Without doubt one could die in one's armchair if fainting without a witness.

The un-clipping of an unconscious subject from his harness after a fall can only be rapidly effected if this intervention has been planned ahead and the necessary equipment and personnel are on standby. This means that no one should plan an operation necessitating the use of a harness without perfect knowledge of the rescue conditions and implications involved. The organizer and operator must just been sufficiently trained.

All these difficulties are added to the other reasons to make provision, at work at least, for the use of protective systems against falls, even small ones, must be limited to cases where no collective solution can be organized and, in this case, to the individual protective equipment prohibiting any fall that those limiting the consequence.

So it is an infrequent risk, but deadly; a risk easy to remedy if one is forewarned, but a risk difficult to admit. It is therefore important that the information be widely spread to all interested parties. This is the reason for my intervention, for my insistence. If this results in saving a few lives which otherwise would have been stupidly sacrificed, I will not regret having bored you a few minutes with my stories.

*[This is the translated text from French of a recorded lecture at the International Fall Protection Symposium, Germany, September 1998, courtesy Peter Ferguson]*

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# Harness Hang Pathology

*By John Green, NSS 39986*

When hanging motionless in a seat harness or sitting in a harness for a long period of time, two conditions can occur: harness syndrome or compression/crush syndrome.

The first, harness syndrome, was originally called hypothermic exhaustion until studies found the cause as the simple act of sitting in a harness. The reason for the study, which was done in France, was partly due to the 15 deaths of cavers in a short amount of time. This study can be found in the French Speleo Magazine - I believe it was done in '91 or '93. (see *HANGING AFTER A FALL AN EXTREMELY URGENT RESCUE* by Maurice a AMPHOUX, this issue. -ed.) Considerable difficulties (blood pressure rose abnormally high, faintness, rapid pulse, diaphoretic and breathlessness) occurred within 15 minutes of hanging.

The second condition which might occur is compression or crush syndrome. Originally, this syndrome was associated with injuries that dealt with extremities being trapped (BFR's, cars, machinery...) for a period of time. The person is fine, they might have a leg trapped under a rock which is impeding the circulation within that leg. While the circulation is not occurring in the trapped leg, toxins (waste by-products of the cells) start to build up within the vessels of the trapped leg, below the compression. The body is always dealing with low, very low concentrations of these toxins without any ill-effects. However, when a crushed extremity (i.e., the trapped leg) is released, the trapped toxins suddenly flow into the circulatory system and shocks the system. This will kill in seconds if not prepared - IV's a must prior to the release. However, this syndrome won't occur in seconds, but an hour or two. This also depends on how large the area is affected and if the circulation is completely or partially shutdown. Hanging in a harness, motionless, for long period of time will produce the same conditions in the legs as if it was trapped under a rock.

Harness hang is a life-threatening situation. A person unconscious, on-rope is in grave danger and must get off immediately. Usually, harness hang will kill them, before the compartmental or crush syndrome will. The best treatment for harness hang is to get the person off rope and on the ground.

Advice:

- A caver experiencing difficulty on-rope, due to exhaustion or technical problems, must have assistance immediately before the situation turns into a harness hang problem.
- A caver hanging completely inert (head back, arms out) must be unhooked quickly by other team members. This person will not survive 30 min.

- A caver should not be allowed to ascend alone, even if they happen to be in very good shape. (pay attention to all team members - accountability in health and location.
- A tired caver should refuse or not be allowed to begin a long or difficult ascent, especially in a wet cave, with out a recovery rest period.
- All vertical cavers must be more than proficient in pick-offs.
- If on-rope for some reason, move - this keeps the muscles moving, which in turn helps in circulating the blood.

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# ONE MAN'S VERTICAL SYSTEM

Revision #1

*By Bob Johnson*

My name is Bob Johnson, NSS # 35023. I have been the Willamette Valley Grotto's vertical chairman for several years. I have been setting up vertical caving rope practices with an obstacle course. I try to simulate real cave conditions the best I can in the practice area. I like doing vertical rope work so I wanted to be able to do all of the obstacle courses easily. This forced me to modify my system many times to make it the easiest for all possible situations. I also wanted it simple and not too expensive. When fellow cavers would let me explain my system and tried it, they all wanted me to write to the NSS to share the features of my system. So here goes!!

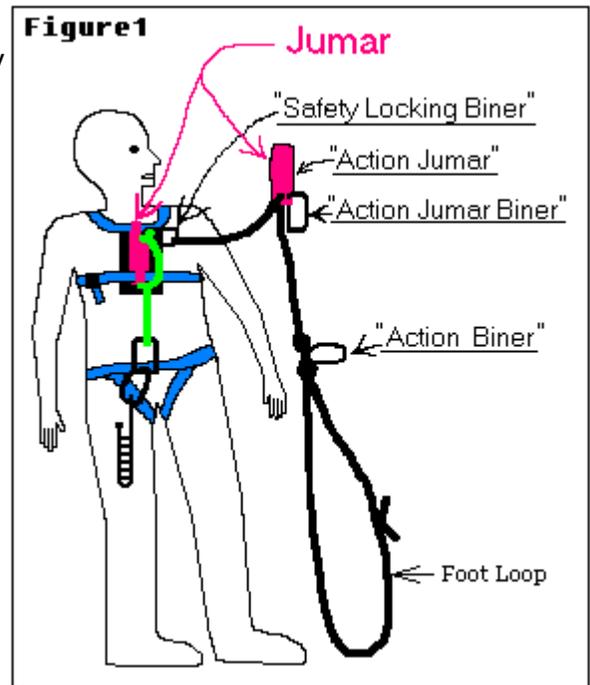
## FIRST THINGS FIRST

The first thing that I would like to do is to quote an article from the book "***On Rope***," Copyright 1987 National Speleological Society, entitled "Climbing Systems" on page 173, reprinted with permission from the NSS:

*"The ideal climbing system should enable the climber to move comfortably and efficiently up the rope. It should provide a secure attachment to the rope, yet be easily removed as well as attached. It should fit the climber properly, be easily taken on and off with ease. It should be lightweight and not bulky. A good system is versatile, able to accomplish a variety of tasks such as being transformed into a rescue haul system. It should be redundant so that any failure will not place the climber in immediate danger. After a component failure, it should have the versatility to be transformed into a system enabling the climber to continue up or down safely. A system should be durable and incorporate interchangeable replacement parts. A good system climbs a wall as well as a free drop and allows a climber to ascend over difficult lips. Systems that fit climbers of different sizes are useful during rescues and training seminars. A great system incorporates the ability to downclimb."*

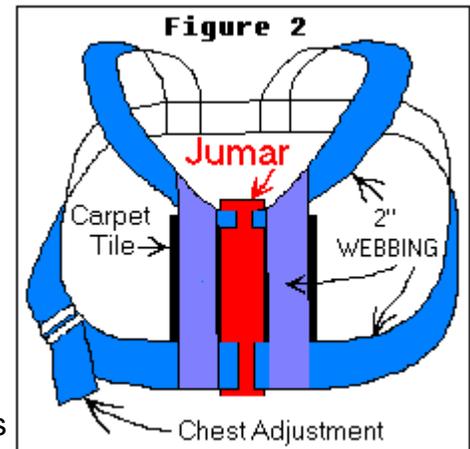
## DESCRIPTION / CONSTRUCTION

The first important thing is a good seat harness. My seat harness is a Gibbs style. The second important thing is a chest harness. (See CHEST HARNESS) They must be connected together since rescue work requires that the seat harness be connected to the chest harness. (See CHEST TO SEAT CONNECTION.) I use two-inch webbing for all of my harnesses.



## CHEST HARNESS

The chest harness is hand made. It has a webbing strap around the chest just under the tender area of the armpits and two shoulder webbing straps connected in back. The webbing around the chest should include an adjustable connection device making it comfortable for both male and female users. The chest webbing and shoulder webbing are sewed to a piece of carpet tile (padding) and through a Jumar ascender. Use a left-handed Jumar here for a right-handed person. I found that the Jumar ascender works the best. The webbing should be sewn tightly and attached safely to the Jumar so that the Jumar is held upright and as high as possible on the chest. The chest strap goes



through the Jumar's handle and is sewn tightly to the Jumar. The shoulder straps go through the top hole of the Jumar. I added two short webbing straps, one on each side of the Jumar. These straps are sewn to the shoulder straps and to the carpet tile and to the chest strap. (See Figure 2.) The short webbing straps help to prevent the shoulder and chest straps from pulling out of the carpet tile. The Jumar's opening for the rope is held away from the body. The Jumar is free to operate smoothly but it is sewn securely to the chest harness so it will not move on the chest. If all was done correctly and you were on your back, you could be picked up by the Jumar's handle like a suitcase. This Jumar, when connected to the seat harness properly and on rope, will allow you to rest in a seated position.

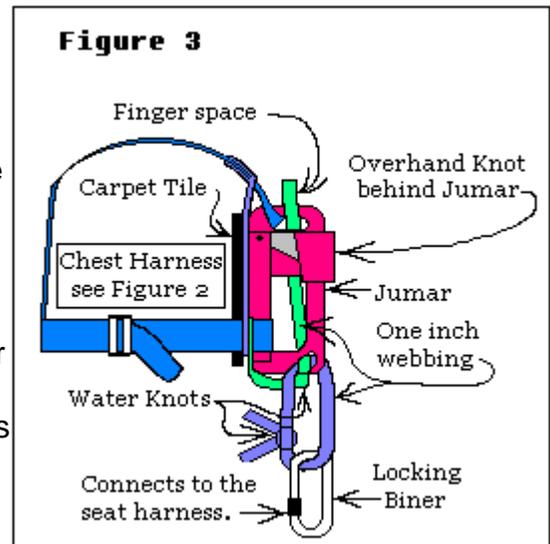
## CHEST TO SEAT CONNECTION

Connecting the chest harness to the seat harness is done with the best one-inch webbing. I suggest a piece that is about four feet long. Find the halfway point. Put one side through the top Jumar hole and tie an overhand knot. (See Figure 3.)

### Overhand knot procedure:

Put both lengths of webbing in your left hand, palm down. The attached Jumar would be to the left of your left hand. The two ends of webbing should now be considered one. With the right hand grab the two ends and put the webbing on top of the left hand to form an eye or loop. Now use your left hand's thumb to pinch the loop so you can hold this loop in your left hand.

With your now free right hand grab the webbing ends and put them through the eye from the bottom side to the top. Pull tight to make the knot.



The end loop should be neat and about two inches long and connected through the top hole of the Jumar. Adjust if necessary. Place one loose end through the bottom hole of the chest Jumar and tie a water knot. If all was done right, the webbing should be smooth and tight when one finger is placed in the top loop above the Jumar. The webbing should be near the rope-guide cam area of the Jumar but on the other side of the metal rope guide. The ends should be sewed to the carpet tile so that the top loop maintains the finger space. (See Figure 3.)

Take another piece of one-inch webbing about two to three feet long and place one end through the bottom hole in the Jumar and through the loop you just made near the water knot. Be sure it's through the loop and the hole because it's your safety connection. The ends should be tied with a water knot at a length that will allow you to connect the webbing to your seat harness with a locking biner. (See Figure 3.) I like to secure the ends by sewing them down.

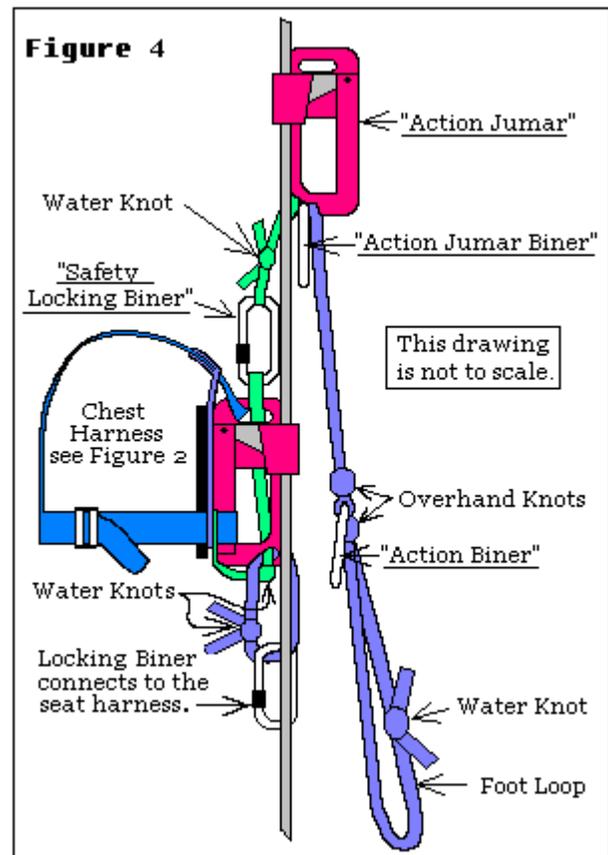
## CHECK IT

If you assembled the chest harness and connected the seat harness connection properly you will stand hunched over. If you didn't, and you are standing straight up, then the chest harness will ride up and be in your face while you are on rope. A properly adjusted harness allows you to be in a comfortable sitting position off rope or on rope, even if you are unconscious. When not on rope, I unclip the chest harness from the seat harness and insert an additional biner so I can stand straight. Leave the two harnesses connected for safety! Be sure to remove the extra biner when you are about to go on rope.

## COW'S-TAIL

A safety Jumar or cow's-tail! Some climbing systems really need a safety Jumar when making a changeover from rappel to climb, or climb to rappel, or when passing an anchor point. So I said to myself: "Why not incorporate it into the basic system. No chance of dropping it then." I use the "Inchworm" / "Frog" climbing system. This system uses a safety Jumar or "action Jumar" (my name for clarity) and it has three things attached to the bottom hole in the Jumar. (See No. 1 through 3.) I used the best one-inch webbing for all of these.

1. This attachment is the safety attachment. In the top loop of the chest harness Jumar, clip in a locking biner. We will call this the "safety locking biner." Be sure to clip it onto the webbing only that is in the top hole of the Jumar. This webbing is your safety connection if the chest harness Jumar is broken. It connects to the seat harness. (See Figure 4.) To make the webbing measurements easier put on your seat harness and your chest harness and connect them together. Clip your chest harness Jumar onto a suspended rope and sit in the harness. While hanging on the rope, clip on another Jumar above your chest Jumar. Use a right-handed Jumar for a right-handed person. I call this the "action Jumar." Grasp the "action Jumar" in the handle with your right hand and put your left hand on the top and sides, then slide it up the rope as far as it is comfortable. This is the travel length that you can use. (I get about 15-16 inches.) Be sure that the rope in the rope-guide cam is close to your head. The Jumar should be in the up position so you can work the release easily with your right thumb. Tie a loop of webbing through the bottom hole of the "action Jumar" and through the "safety locking biner" that is clipped onto the loop at the top of the chest harness Jumar. Be sure that the "safety locking biner" is held up tight when you tie your water knot. (See Figure 4.) I also sewed the ends down.



2. You should still be suspended on the rope. The next attachment uses a piece of webbing about eleven or more feet long, depending on your height. Find the halfway point and put one end through the bottom hole in the "action Jumar." Pull one side down about a foot and a half to make it uneven. Push the "action Jumar" up as far as the attachment to your chest harness will allow. The loose webbing should now be hanging in front of you. Grab about the middle of the two ends and tie an overhand knot in the webbing with the knot at the midpoint of your chest Jumar. Now tie another overhand knot one inch below that. Spread apart the short section between the two knots and put in a non-locking biner. This is the "action biner." (See Figure 4.) Next, raise one knee so your upper leg is horizontal with the floor. Put one end of the webbing under your foot and tie a water knot with the remaining end. The knot

should not be under your foot but along the side of your leg. This is your foot loop. You may need to adjust this after you see how it works. I sewed the ends.

3. The last attachment is a non-locking biner placed in with the webbing in the bottom of the "action Jumar." It will be called the "action Jumar biner." (See Figure 4.)

## **RAPPELLING DEVICE AND EXTRA ITEMS**

A Rack or SRT (Single Rope Technique) for rappelling is locked onto the seat harness with a locking biner. This concludes the construction. Extra items for all the features would be: a pulley, three extra biners, short loop of one-inch webbing, long loop of one-inch webbing, prusik loop of small diameter climbing rope, and a long line of small diameter climbing rope for the 2 to 1 rescue procedure.

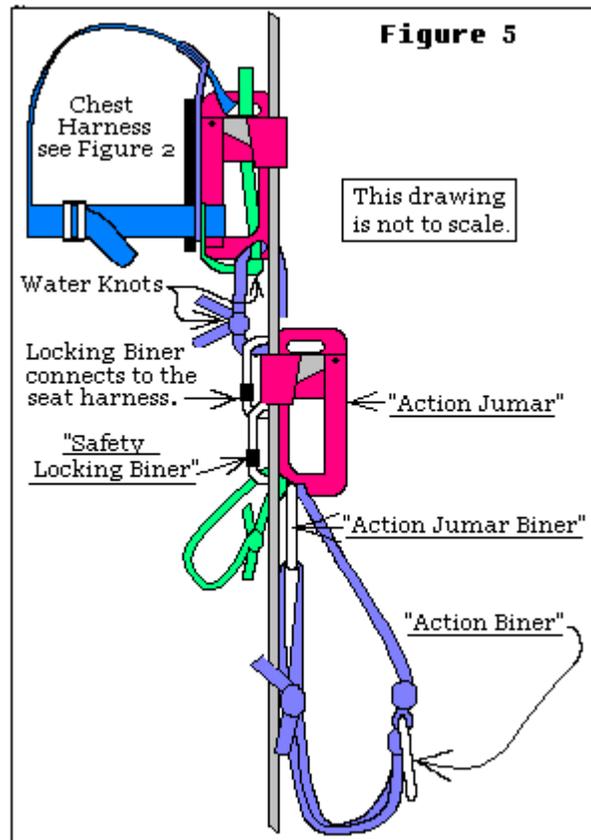
## **NO CHICKEN LOOPS**

Why such a big foot loop and no chicken loops? Chicken loops indicate to me that the system will let you go upside down if one component fails. No one should ever have that happen! If your system would do it, fix it! My system does not need the chicken loops because if one component failed it would not let the person hang upside down. When climbing, the big loop is used to put your feet and your knees in when you want to rest completely. Your legs now make a nice place to put things that you want to set down temporarily. If the "action biner" is clipped to your descending device, when you are rappelling, the big loop can support your feet on a free drop rappel.

## **HOW IT ALL WORKS**

With both Jumars on the rope, sit suspended. You now can put one or both feet into the foot loop. Raise your foot loop leg(s) and at the same time slide the "action Jumar" up as far as it will go with both hands. I like to use both hands for exercise. Stand in your foot loop and at the same time pull down on the "action Jumar" and toward your chest Jumar. Your chest Jumar should feed the rope through. Sometimes it doesn't because the rope is very short below you. You can pull the rope down with one hand or trap the short end with your heels for starting. Next, sit down in the harness and repeat the process. When I am against a wall, I use one foot for balance and one foot in the foot loop. The large loop enables me to switch feet easily. This sit-stand method of climbing can easily cause a bouncing rhythm when you climb. If you do this, the rope above you may be sawed in half by a protruding rock. To prevent the bouncing rhythm from occurring, make the end part of your movements with a smooth gradual stop.

A second way to climb is to move the "safety biner" and clip it onto your seat harness biner. Move the "action Jumar" below the chest Jumar and clip it onto the rope. Take the bottom of the foot loop and clip it into one of the non-locking biners below the "action Jumar." You now can use the sit-stand method with one finger pulling up the bottom Jumar or put a bungee cord in it. This position is ideal for climbing up over a difficult lip where the rope is on the ground at the top of the climb. (See Figure 5.)



## DOWNCLIMBING

With both Jumars on the rope, sit suspended. (See Figure 4.) Lift your feet up and move the "action Jumar" down close to the chest Jumar and lock it. Stand in the loop and move the chest Jumar down almost as far as it can go by squatting down, and then lock it. Sit down and raise your feet and move the "action Jumar" down close to the chest Jumar and lock it. Stand in the loop.....etc.

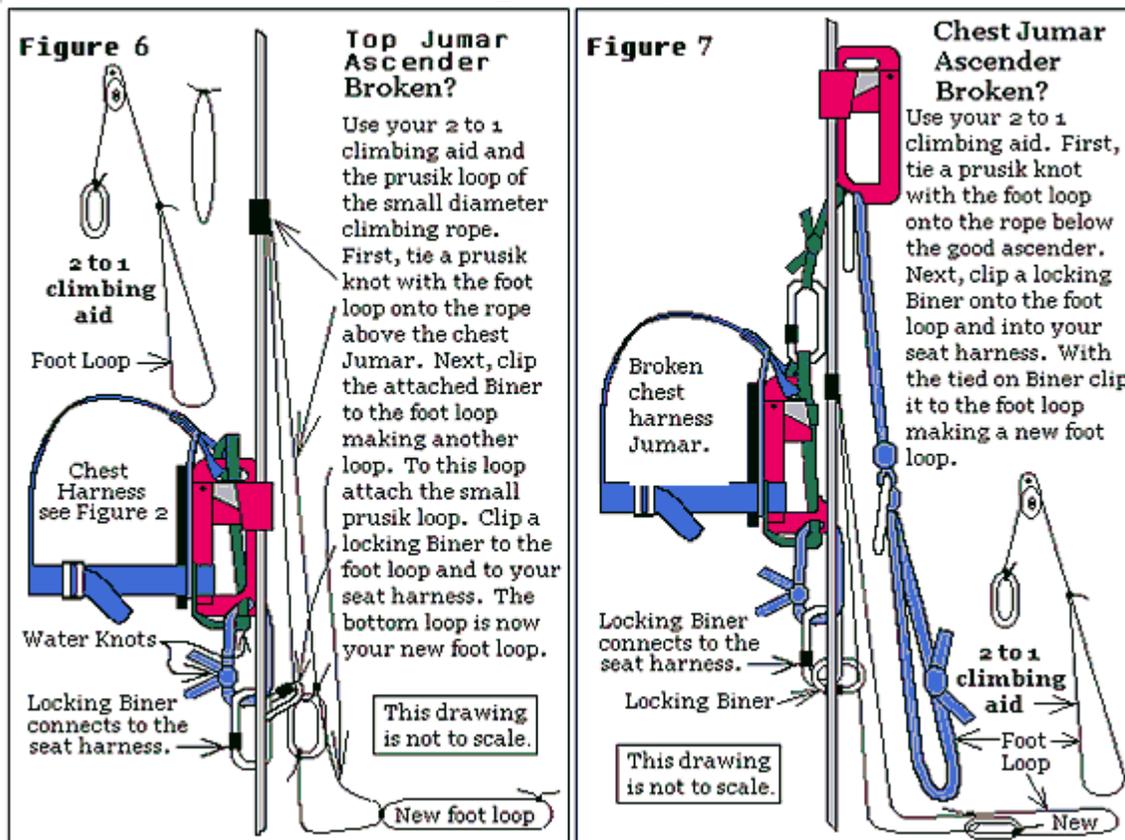
## RESTING

When you need to rest, the chest harness Jumar holds you in your last position. If you put the "action Jumar's" foot loop at the right height you can rest in a seated position. In some other systems, when you stop climbing, you have to squat down to get a device to jam so you can rest your muscles. Then you have to waste energy by standing back up to continue climbing.

## IF ONE FAILS

If one Jumar should be broken or damaged by a rock, you still have one left to climb with. This is done by looping the rope, below the Jumar, around one raised foot. Bring up the down side of the rope and put it next to the rope above your foot. Grasp the two ropes in one hand to make a crude ascender. The sit-stand method still works up or down, it just takes longer and more energy. You have to keep making another crude ascender each time you use it.

You can also use your rescue 2 to 1 climbing aid and your prusik loop, from your extra items, to replace the broken Jumar. (See Figures 6 & 7.)



## THE CHANGEOVER

The rappel changeover to ascend is very easy. I put on my climbing system when I rappel. You never know when you may have to change directions of travel when on rope. (See Figure 4.) First you tie off your rappel device, then clip your "action Jumar" onto the rope above the rappel device. Then remove your rappel device from the rope and clip on your chest Jumar. Start climbing.

The climbing changeover to rappel is easy too. Just stop climbing when the chest Jumar is near the "action Jumar" and then clip the "safety locking biner" into the "action Jumar biner." Downclimb the very short distance to release the pressure on the chest Jumar and release it from the rope. You now have access to the rope all the way to the bottom of the "action Jumar." Place your descending device on the rope as high as is easy. Lock it off. Next, unclip the two clipped together biners by standing in the foot loop and opening the non-locking biner. (Never unlock a locking biner when on the rope unless you are changing climbing modes described in HOW IT ALL WORKS.) Sit down in the harness, raise both feet that are in the foot loop, and remove the top Jumar. Release the descending device's lock carefully and rappel down. Sometimes some people let the descending device slip down so far that they can't get their weight off of the top ascender. If this happens just clip the "Action Biner" on the rope above the descending device. Stand in the foot loop and move the top Jumar down enough to get your weight onto the descender. Remove the ascenders and you are ready to

rappel.

The tyrolean traverse changeover from a vertical rope is also easy. You just climb up, or down, so you can get your seat harness as close to the tyrolean traverse as you can. You will need from your extra items, the pulley, a short loop of webbing, and a locking biner. Without unlocking the seat harness biner, thread the loop of webbing through the seat harness biner. Then take the other end of the loop and put it through the first loop, trapping the seat harness biner on the loop. Then use the extra locking biner and clip it onto the other end of the webbing. Put the pulley on the tyrolean traverse and clip the biner onto the pulley. You may have to put your legs over the tyrolean traverse and raise your stomach to clip the biner. Downclimb so that almost all of your weight is on the tyrolean traverse. Unclip your chest Jumar. Bend one knee and make a loop or a circle around the toe of your foot with the rope you just climbed. Hold the down side of that rope up below the "action Jumar" next to the "action Jumar's" rope and grasp both ropes with one hand. Put your weight on the loop you just made and release the "action Jumar" with your other hand. If your tyrolean traverse is at a high point, then you can go for a ride by letting go of the foot loop rope. Point your toe, and the rope peels off. Watch out for your hair, or whatever, getting caught in the pulley.

If you don't want to coast, just clip your "action Jumar" onto the high side of the tyrolean traverse. Release the rope in your hand and undo your toe. When you are ready to travel down to the middle of the sag in the tyrolean traverse, you can downclimb the rope. You do this any way you can. One way is to rock your weight so on the upswing you can move the "action Jumar" down a little. Another way is to go hand over hand. Lastly, if the rope is very steep you can clip on your chest Jumar and downclimb. Remember the "action biner?" You can use it to support your feet by clipping it onto the rope and putting your feet in the foot loop.

Once you get to the bottom of the sag and you want to go up the other side, take everything off the rope except the pulley and the link hooked to your seat harness. The webbing link that was put on the seat harness will allow you to turn around without binding the pulley. Reverse the above procedures to get to the other end.

Once you can get to the other end's down rope, or up rope, just clip on your chest Jumar and your "action Jumar" and climb up so you can take off the pulley attachment. You are now ready to climb up or down without making the foot loop that was mentioned before.

## **PASSING OBSTACLES**

Climbing past a knot or anchor point or changing ropes is very easy. You just move your two Jumars close together and close to the object. Then move the Jumar that is closest to the object, past the object. Downclimb or climb up to put the remaining Jumar close to the object. Move the first Jumar some more and then pass the object with the last Jumar.

To change ropes just clip the "action Jumar" onto the other rope, shift your weight and move the other Jumar over.

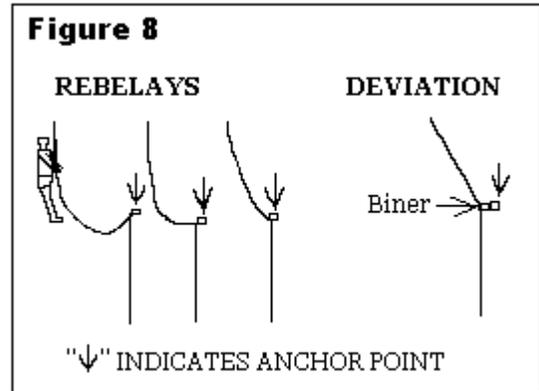
To rappel past a knot, you have to execute a changeover to the downclimbing mode. Pass the knot, and then change back.

## REBELAYS

(See Figure 8.) To rappel past a reanchor, a looped rebelay, a loose rebelay, or a tight rebelay, all you have to do is change over to a climb and downclimb past the knot, or the anchor, or whatever. Change back to a rappel and you are on your way.

## DEVIATION

(See Figure 8.) The loosely redirection biner rebelay (deviation) can be passed by rappelling an inch or two below the biner and locking off the descender. Take your "action Jumar biner" and clip it to the anchor. Put your weight on the foot loop. Move the redirection biner from below your rappel device and attach it on the rope above your rappel device. Put your weight back onto your descender and unclip the "action Jumar biner." Unlock your descender and finish the rappel.



When climbing up and past a rebelay treat it like any other obstacle, except remember that you have an "action biner" and an "action Jumar biner" to help you shift your weight.

## CLIMBING SLOPES

When ascending a slope, the foot loop is not needed. Secure your foot loop out of the way by using one or more of the non-locking action biners.

## TANDEM CLIMBING

The "action biner" is useful when you are on the top of a "tandem" climb. The "action biner," when clipped to the rope, will redirect the rope away from your crotch. This makes you more comfortable, helps to keep you more upright, and makes your climb easier.

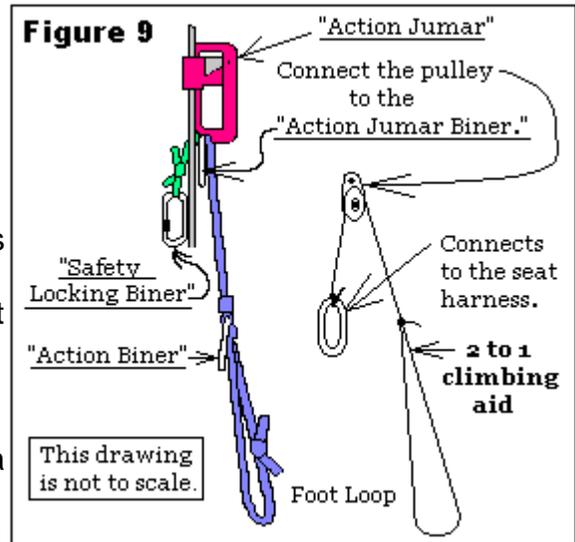
## ROPEWALKER SYSTEM

Some people just have to have a ropewalker system. On my system, for the very long climbs, I can add a foot ascender attached to the ankle/foot area. A bungee cord attached to the top of the ascender and to the harness makes this work very well.

## RESCUE

If you need to rescue someone who is on the rope and you are below them, this system will let you climb past. You just treat them like any other obstruction, except that it is more awkward. As you pass the person, clip onto the upper part of the person's harness with your extra biners and webbing and then to your seat harness. Make the webbing length sufficient so you can climb above the person and you won't hit them with your feet.

I found some people so heavy that I could only lift them about one or two inches at a time. This was unacceptable to me, so I found that a 2 to 1 climbing aid was helpful. (See Figure 9.) From your extra items, clip the pulley onto your "action Jumar biner" and make a new foot loop from the long line of small diameter climbing rope. Copy the one that's on your system, but leave off the extra knot and the "action biner." Take the free end of the rope and put it through the pulley. Attach the end to your seat harness. With the "action biner" missing, you now can raise your legs higher. By yourself, you can get about the same amount of climbing distance. With a victim, you still climb with the "action Jumar" as before, but much easier. It helps to have the loaded webbing in front of your foot loop and between your toes.



If you want to rescue someone who is below you, you may have to downclimb all the way. I think you will be glad to have my system for that.

## DISCLAIMER

Caving and climbing ropes or rappelling is dangerous. If you would like to build my system, go ahead and do it, but have someone who has been doing vertical caving for many years check your work. After you've constructed the system, also have them make sure you are using it correctly.

## QUESTIONS

If you have questions about my system or would like to communicate with me, I can be reached by email: [robert.johnson56@worldnet.att.net](mailto:robert.johnson56@worldnet.att.net).

# Choosing Haul Systems

*A Paper by Carroll C. Bassett*

In making choices as to which haul system to use the haul team leader must actively integrate the qualities of the various mechanical advantage (MA) systems, see chart, with the physical conditions at hand and the resources available. Generally the most efficient system will be the simplest but will in turn require the greatest number of haulers, i.e. the 1:1. To determine if this is an appropriate choice one needs to be able to assess the *force* requirements for the job at hand and link those requirements with the *force* available, i.e. the force that your team will be able to exert over the period of the lift.

It seems to be generally accepted that the average rescuer can exert a force of 50 lbf although some studies have shown average individuals *grip strength* to be more in the neighborhood of 30 lbf.

If we have 10 haulers then we can expect a sustained output of between 300 and 500 lbf, which, given a perfectly frictionless system would be capable of raising a 300 to 500 lb load. If the raise is relatively short then the 500lbf choice in team assessment will probably suffice, but in the case of a long raise in which the team will be required to exert themselves over a prolonged period of time the 300lbf force assessment will be a lot easier on our haulers and is probably more appropriate.

We next need to determine what the actual load will be. If we have a patient in a basket with an attendant, we can assume that we probably have a combined weight of between 400 and 600 lbs. If we are sure that this weight is close to 400 lb then our team's *force* will probably be adequate for a short haul using a 1:1 MA system. If on the other hand the combined weight is closer to 600 lb, it's a long raise, or there is significant friction in the system, then a 2:1 MA system will be required. The source of this friction might be directional pulleys, edge rollers or even rope pads placed at the lip and other areas where the rope makes contact with potentially damaging surfaces.

In setting up our 2:1 MA system we need to take into account the length of the raise and be sure that our haul line is at least twice the length of the raise. Another consideration is the possibility of the two halves of the haul line becoming twisted around each other. One cause of this is from basket rotation in a free drop. This will greatly increase the friction in the system possibly to the point of making the system unworkable and therefore dangerous. A further danger can come from branches or other objects becoming caught in between the haul line and the pulley attached to the load as it rises. If these conditions are felt to be a significant risk, then a single haul line can be *ratcheted* up using a 2:1 MA.

It should be noted however that this scenario shares the same disadvantages inherent with higher MA systems. These systems must periodically be stopped and reset. Once the haul is started with a simple 1:1 or 2:1 MA, the load can be raised continuously until it reaches the top. This can save time and give the patient a smoother ride, two important goals in a rescue environment.

However if our resources are not sufficient to accomplish the lift with either a 1:1 or 2:1 MA then a 3:1, 4:1 or higher MA will be required. Space can be a determining factor in choosing a system; if your haul team is small because there is no room for more bodies, you will need to use a higher ratio MA system.

Both 3:1 and 4:1 MA systems have disadvantages and advantages over one another. As previously mentioned both have to be *ratcheted* or *reset*. Besides being more equipment intensive they also introduce greater losses into the lifting system through friction (see chart). A further disadvantage of the 4:1 MA is that it must be *reset* after only traveling half of the distance it requires to be set up in: i.e. the 50% collapse rating in the chart. This can be a real problem in a tight space, creating the necessity for very short lifts between *resets*. A 3:1 MA or a **Jigger**\* would probably be a better choice in this case since they both collapse completely. The standard **Z rig** which has a 3:1 MA has the distinct advantage of requiring only one rope to operate while the 4:1 MA or **Piggy-Back** requires two. In the end, however, the higher MA systems may be the better choice simply because of their greater lifting capacity using fewer people.

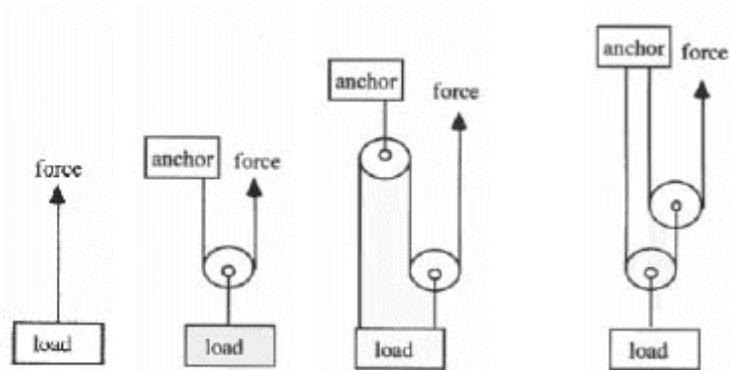
A good rule of thumb is to use the simplest system that will allow your resources to accomplish the task: K.I.S.S.

NOTE: I have purposely left out any reference to belay systems, progress capture devices, etc. in an effort to concentrate on some of the considerations for choosing a haul system. Their absence in this discussion does not imply their lack of importance; it is simply beyond the scope of this work.

\* **Jigger**. A 4 or 5:1 MA system composed of two double sheave pulleys rigged one above the other. When the rope emerges from the pulley attached to the anchor, the system has a MA of 4. If the system is inverted and the rope emerges from the pulley attached to the load, the system has a MA of 5.

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**Common M.A.  
 System  
 Characteristics**



Mechanical Advantage:	1:1	2:1	3:1	4:1
System Friction ** :	0%	5%	10%	10%
Force (L=load):	1L	1/2L + 5%L	1/3L + 10%L	1/4L + 10%L
Collapse % :	100	100	100	50
Resets Required?	No	No	Yes	Yes

\*\* Good low friction pulleys generally are in this range, some are much worse. At lower loads, bearings are more efficient than bushing but at higher loads this can reverse. Also the force to bend kermantle rope increases with load (inner fibers sliding over each other under increasing tension). The addition of edge rollers and directional pulleys will also contribute to system friction and should be considered.

**Thank you for your time.**

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# THE PIGTAIL KNOT SHUNT

*By Oren Tranbarger*

## **Introduction**

One of the skills required for vertical competency is rappelling over a knot. Changeover modes and climbing up over a knot are easy compared with rappelling down over a knot. A Mitchell system is perhaps the best conventional system to use for downclimbing over a knot, but some cavers do not use a Mitchell system or might not have the necessary gear (double-roller chest box) to implement such a system. After practicing various techniques in rappelling over a knot and contemplating the problems encountered, a new technique was developed for the required maneuver. This technique allows the caver to remain seated in the seat harness and requires no upper body strength or special equipment. The pigtail knot shunt can be safer since three points of contact are usually maintained while hanging on the rope. The following technique is especially easy to use if a self-belay device is used.

## **Self-Belay Devices**

The merits of self-belay devices are undisputed unless such a device is poorly designed and interferes with rappelling. Recent incidents have occurred where a life might have been saved had the unfortunate victims been using a self-belay device and always maintained a second point of contact on the rope. Conventional self-belay devices are described in *On Rope*. Also, a bar-release design for a Gibbs that I have found useful is described in *The Texas Caver*, June 1991, pp. 63-64.

## **Pigtail Knot Shunt Design**

The pigtail knot shunt consists of a Jumar ascender tied to a 7/16-inch rope about 15-20 feet long. The end of the rope should have a loop big enough for standing (if that should be necessary) and a knot about 3 feet above the loop for safety. In application, the Jumar is attached to the rope about 7-10 feet above the knot on the standing rope. The caver simply transfers over to the pigtail, rappels past the knot, and then transfers back to the standing rope below the knot. Once on the standing rope below the knot, normal rappelling is resumed.

## **Rappelling Equipment And Procedures**

In rappelling over a knot, the accessory equipment required is: (1) the pigtail knot shunt (carried on the seat harness); (2) a self-belay device; and (3) a safety. If a self-belay device were used that cannot be released under load, then an ascender would be used on one foot to rise up on the rope for releasing the self-belay device. The following steps describe the procedure:

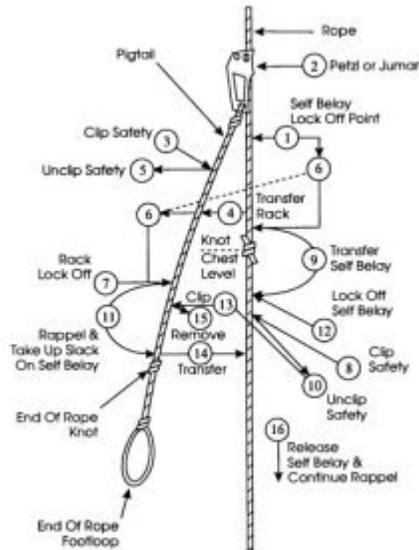


Illustration By Blake Barr

1. Rappel down above the knot and lock off using the self-belay device about 5 feet above the knot.
2. Attach the Jumar and the pigtail above the self-belay device as shown in the figure.
3. Attach the safety on the pigtail as shown in the figure at chest level with slack in the tether.
4. Transfer the rack from the standing rope to the pigtail.
5. Unclip the safety from the pigtail.
6. Continue rappelling on the pigtail by releasing the self-belay device.
7. Stop the rappel at neck level with the knot and tie off the rack.
8. Attach the safety about 1-foot below the knot on the standing rope as shown in the figure.
9. Remove the self-belay device above the knot and reposition it below the knot.
10. Remove the safety in Step 8.
11. Untie the rack in Step 7 and continue rappelling on the pigtail.
12. As rappelling continues, lock off the self-belay device.
13. Reattach the safety on the pigtail above the rack as shown in the figure.

14. Transfer the rack from the pigtail to the standing rope.
15. Remove the safety in Step 13.
16. Continue rappelling on the standing rope by releasing the self-be-lay device.
17. After completing the rappel, one of two things will happen:
  - (1) another caver will follow; or
  - (2) the first one to rappel will ascend. In the first case, the following caver would rappel down slightly above the Jumar. At this point, simply reach below, detach the Jumar, rappel farther down the rope, and reattach the Jumar overhead. After reattaching the Jumar, the above procedures would be repeated. If following carets did not wish to use the pigtail, any standard technique for downclimbing over the knot could be used.

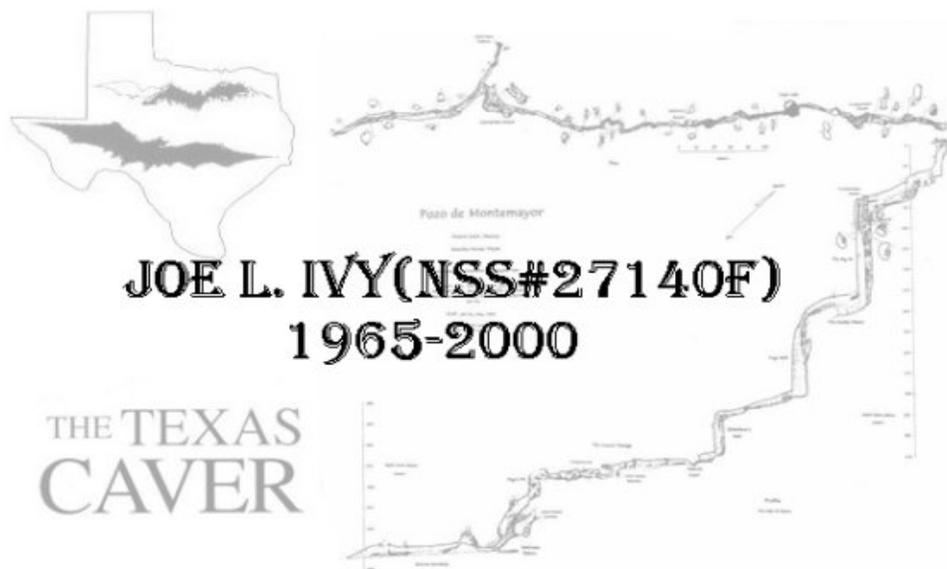
On ascending, the first one up the rope would climb over the knot using any conventional technique. On the way up, the Jumar and pigtail would be detached and carried to the surface.

## **Summary**

The above technique for rappelling over a knot always maintains two points of contact, minimum, on the rope. With the exception of brief transfer and rappelling periods, three points of contact are maintained. Although more steps are involved than conventional techniques, the advantages are that: (1) a sitting position can be maintained throughout the procedure; (2) no super upper body strength is needed; (3) no special climbing gear is required; and (4) the pigtail does not hamper other techniques that might be used for downclimbing. A self-belay device should be used in performing the above procedures. With practice, the pigtail technique can be accomplished quickly without much thought.

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On the evening of September 30, 2000, Joe Ivy died from a fall while performing a Texas record-high dome climb in O-9 Well Cave. Joe was one of the most skilled cavers in Texas, especially in vertical and cave rescue techniques. His death is a tremendous blow to cavers throughout the country, both from sorrow and concern on how someone so skilled could have perished.

Joe began caving with the San Antonio Grotto at 16. His life story is one of persistence toward excellence. No one expected he would remain a caver for long. A slow-moving, polo shirt-wearing preppie and the drum major of his high school band, he was somewhat nervous about doing the things necessary to caving. But by the time he reached 18 that had all changed. By his late 20s he had gained international respect for his strength, caving skills, leadership, and irreverent good humor.



Among his many caving accomplishments are hard-charging explorations of hundred of caves throughout the U.S. and Mexico, most of which he surveyed or helped survey. Joe played key roles in pushing/surveying the longest caves in Texas. He led the push of Pozo de Montemayor, and through his first bolt climb made it by far the deepest cave in northern Mexico at -515 m. He was a regular member of the Sistema Cuicateca (Cueva Cheve) Project, one of the deepest caves in the world. He recently headed the exploration of Mexico's Cueva de la Puente, which had long been written-off as a short cave, and pushed it to over 8 km in length through some of the most spectacular passages anywhere. His list of expeditions and projects are too numerous to mention.

Joe cared deeply about the caving community and served it in many capacities. Over the years he had been chairman of the Bexar Grotto and Texas Speleological Association (TSA), he served as the Texas Regional Coordinator of the National Cave Rescue Commission, and at the time of his death was Chairman of the TSA Safety and Rescue Committee and co-editor of the Texas Caver. He had published over 60 articles on caving, including his many trademark insightful, no-nonsense reviews of caving equipment and techniques. He trained countless novices, led and assisted with numerous cave rescue training seminars, and pioneered new, effective cave rescue techniques, especially small party self-rescue methods (he was writing a book on the subject) that could be needed in the remote caves he was so fond of exploring. In 1997, the NSS recognized Joe's achievements and made him a Fellow of the Society.

Joe's passion for caving spilled over into his work. He was the co-owner of Gonzo Guano Gear, and took justifiable pride in designing fine caving equipment that he rigorously field-tested on his many expeditions. With his Geography degree in Environmental Management, he regularly worked for 13 years as a contractor in karst hydrogeological, biological, and related environmental research. During his last couple of years, he was increasingly being called to teach courses in vertical and rescue techniques.

Joe Ivy is survived by his companion, business partner, and co-editor Becky Jones, by his brother Marvin Ivy, sister-in-law Kristy Ivy, niece Ashley Ivy, and a large, internationally extended family of cavers who loved and respected him. A fund to support cave exploration is being established in his name. Those wishing to make donations to the "Joe Ivy Endowment for Cave Exploration" can send them to the NSS office. Joe's passing has left an "Ivy-sized" hole so large in our caving community that we may never be able to push far enough to find its end.

George Veni

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# Accident Report: Joe Ivy, O-9 Well

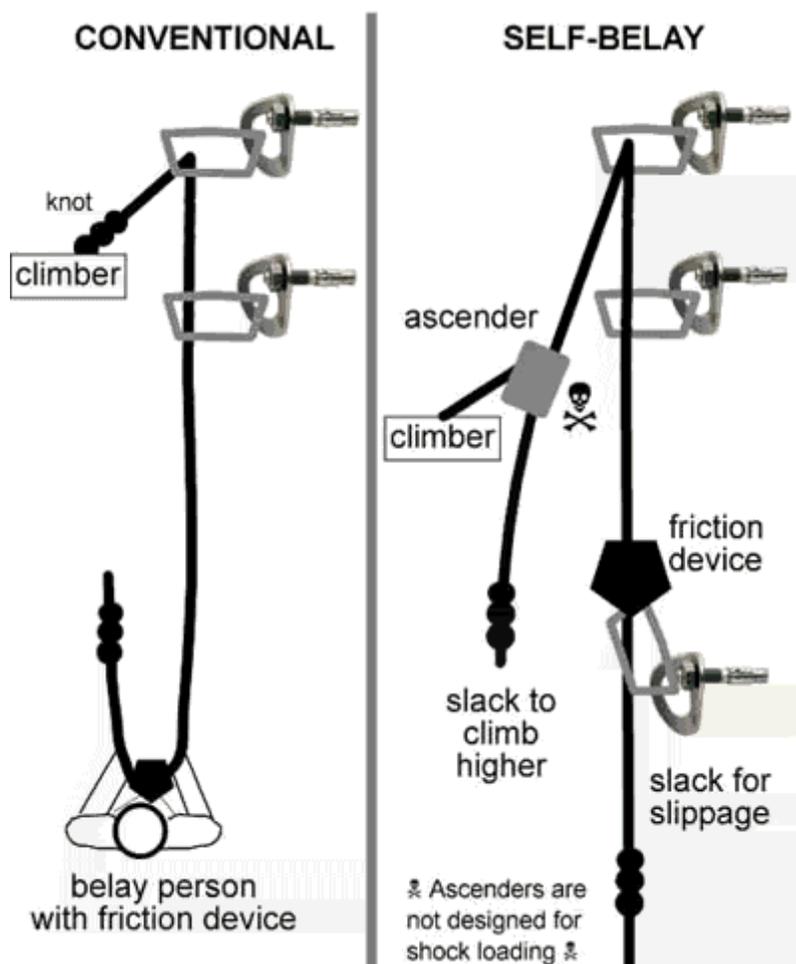
Crocket County, TX -- 30 September 2000

Edited by Rebecca Jones & Peter Sprouse

Contributions by: Rod Dennison, John Fogarty, John Ganter, Rebecca Jones, Dr. Jay Kennedy, Bill Mixon, Alan Montemayor, Bill "Carlos" Nasby, Matt Oliphant, Peter Sprouse, Tim Stich, Bill Storage, George Veni

O-9 Well is one of the deeper caves in Texas, around 100 meters deep. From the bottom of the 39-meter deep entrance drop, the downstream section continues down five more rope drops to a sump. In the dome above the sump, Joe had seen what looked like an infeeder in the ceiling that he felt might lead to more cave passage. In March 2000, Joe Ivy and Tim Stich made plans to do a bolt climb up the dome.

## Aid Climb Project Background



To climb in O-9 Well, Joe and Tim used a cordless hammer drill and several types of protection in addition to expansion bolts. What was unique to this climb was the self-belay system. First, Joe drilled and set two bolts at the base of the climb, to which Joe attached a Kong Slyde. This shock absorbing mechanism is a small metal plate with holes drilled in it. Then the rope is threaded through the holes such a way that as to create friction. The purpose of the Slyde was to turn the 9mm static rope they were using into a dynamic system capable of absorbing the energy of a falling climber. Under normal static load this cord would not travel through the Slyde, but upon dynamic load it was set up to slip through the device and absorb energy.

As the bolt climber made upward progress, the rope connected to the Slyde went up through the protection carabiners and then down to the climber. The ascender (or in some cases two ascenders) of the lead climber was the attachment point to the lead rope. An ascender was used in order to conveniently adjust the length of the belay rope, something that in a normal belay system would be done by the belayer. On the first climbing trip Joe and Tim both took falls onto this rigging and it easily absorbed the energy of the fall. On average, the falls were around 4 meters including movement through the Slyde. Tim says that in the case of his fall there was around 7 meters of rope below the top piece, making his fall somewhat less than a factor 0.6. In both cases they were using a new piece of protection called a removable bolt (RB). These are reusable wired camming devices designed to be inserted into a drill hole, the use of which would reduce the number of bolts that they would have to place. These come in a variety of sizes. Joe and Tim used both 3/8 inch and 1/4 inch RBs on the first climb. Tim took a fall when a 1/4 inch RB pulled unexpectedly and Joe took a fall on a 3/8 inch piece, which he felt he had placed poorly. It was extremely difficult to avoid getting some water and mud on the RB before it was inserted. This may have adversely affected the performance of the protection. They decided to abandon using the 1/4 inch size RB and stay with the 3/8 inch ones.

## **The Day of the Accident**

Joe and Tim made a total of five trips to continue working on the climb over three weekends. On the last weekend (30 September), they had cleared a muddy section that had made progress on the second weekend unusually difficult. Thick, clinging mud made manipulating gear almost impossible. The final section to the very top of the bolt climb, which was about 50 meters off the floor, was relatively mud-free and on what appeared to be good rock. Joe took the first shift on the climb, as he usually set up the Slyde rigging at the belay point.

After making at least six meters of progress, Joe descended to the fixed line below him and rappelled to the base of the wall. He remarked that he was going to eat and get something to drink. From time to time during that day's climbing other cavers on the trip visited the bottom room. Some were still there when Joe descended the standing line. Tim got a wrench and some carabiners from Joe and also the adjustable one stirrup etriers, which Joe had designed himself. Tim preferred these to the standard multi-step ones Joe also had on hand. Tim climbed up to the anchor for the fixed line and then attached himself to the lead rope. The rope had been passed through a vertical line of 3/8 inch bolts to Joe's last protection, a bolt. (During this part of the climb they used three-inch wedge- and

sleeve-type bolts.) Tim switched his ascenders to the end of the rope that came down from the carabiner in Joe's last bolt and climbed to where the lead continued.

Along the way Tim cleaned carabiners and hangers from the protection Joe had placed, leaving the last two bolts. When he reached the top bolt, he transferred the hammer drill and bolt kit that were hanging on the bolt to his harness. From there, he continued the climb by the method they had established. This involved clipping his cow's tail into the bolt hanger of the topmost bolt. He then attached the etriers to the bolt carabiner which also contained the rope. This allowed him to then stand and attach a fifi hook to the bolt hanger. The fifi hook is a flat metal hook attached to his harness with a short piece of cord, allowing him to get as close to the bolt as possible.

From there, he adjusted the etriers to a position that allowed him the highest comfortable step from which to drill a new bolt hole higher up. After setting a new bolt, he then hung a carabiner from it. He put one etrier on this carabiner to use it to pull up on. This allowed him to thumb his chest ascender and get slack from the lead rope. Tim then stood up, clipped the rope into the higher carabiner and moved slack down through his two ascenders. Then he could remove his cow's tail and fifi and climb up to the new, higher bolt. This technique does create a loop of slack not normally seen in a standard belayed climb, where the belayer would be paying out slack as needed by the climber's ascent.

Joe performed these same actions while he climbed. However, earlier in the climbing project Tim had decided to use both of his ascenders on the belay rope, while Joe continued to use only the seat Croll to attach himself to the belay rope. Tim also had decided to use 3/8 inch expansion bolts exclusively. Although the 3/8 inch RBs appeared sound to him, he had enough expansion bolts with him to use for all of his placements. Joe continued to use the 3/8 inch RBs and had placed one on his first shift. At no time did they placed two RBs in a row, always placing a bolt above an RB.

When Tim finished his shift, he was within 4.5 meters of the top of the climb. A hole, two to three meters in diameter, could be seen at the summit of the climb. A low crawlway appeared to go off in one direction, although it was possible that it was merely a flat roof with a slightly hollowed out ceiling. He drilled two final bolts and tied a double figure 8 knot to make a standing line. At this point, it looked like the lead rope might not reach the top. In any case, Tim had run out of hangers and was exhausted. He decided to end his shift and let Joe finish the final pitch. At most, it would take four more placements. Tim left the two bolts at the top for Joe to climb up to. As he rappelled, he removed hangers and carabiners to give to Joe.

## **The Accident**

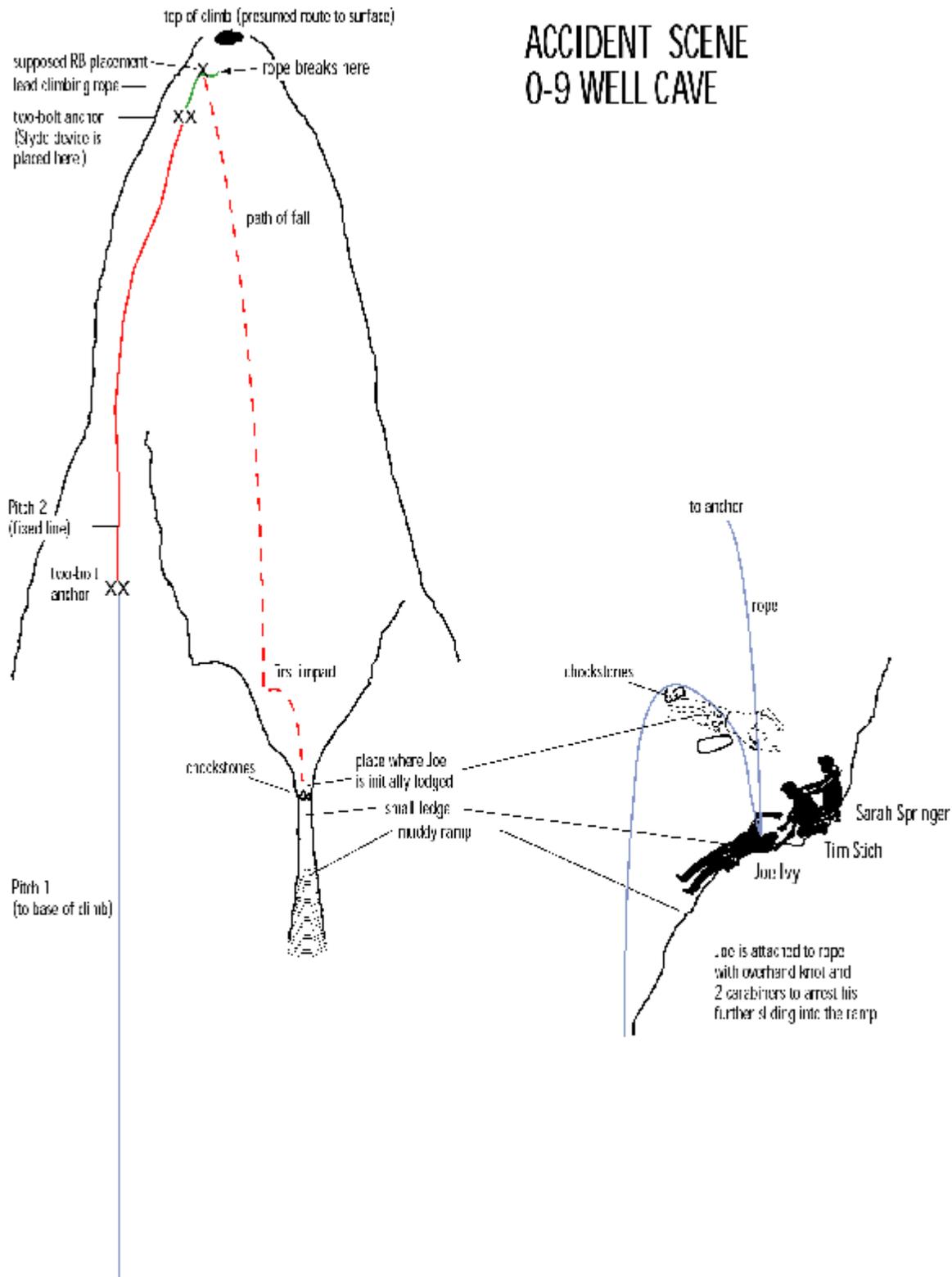
Joe had gotten rest, food, and water, and was in good spirits. Tim told him he had two bolts at the top of the lead rope and might need another rope. Joe coiled one and attached it to his harness. Joe ascended the rope and disappeared from view into the darkness of the upper dome. The other cavers sounded like they were again visiting the bottom room, and Tim heard some voices and saw flashes of headlamps. He could occasionally see the dim glow of Joe's LED array high above him. Then, Tim heard what sounded like a brief

exclamation from Joe and then a loud, resounding crash. Many times in the past, large chunks of mud and some rock had fallen on the climb, but this was much louder. Tim called up to Joe, but there was no response. More alarming still, Tim could no longer see any light above him. Tim decided that Joe must have had a mishap.

Tim shouted up to Joe several more times. One of the approaching cavers, Sarah Springer, heard the shouting and spoke out to Tim. He told her that he needed help. Sarah passed the word up and in seconds someone was making his way to the surface. At this point, Tim began to hear Joe moaning and trying to say something. Sarah continued descending into the room where Tim was. Tim quickly put on his ascending gear and climbed the standing line. Joe's moaning was coming from a point well below the lead, which frightened Tim. When he finally saw Joe, he could see that he was wedged within a slot above a muddy ramp they had discovered during their previous trips. Joe's legs were slightly raised, his helmet was missing (it was later found and put back on his head), and smears of blood were on the left wall. Joe continually complained of difficulty breathing. It appeared that Joe had fallen from 12 to 18 meters, hit a steep, sloping ledge on the left and then wedged into the slot above the muddy ramp. Tim climbed above the slot and then down climbed to Joe from behind.

Tim noticed that Joe was not attached to any rope. That was the first thing he decided to attend to, as it was very possible that Joe could slip down the ramp and off the wall. He made a quick overhand knot in the rope below him and attached Joe's harness to it. He then asked Joe about his injuries. Joe said, "Can't breathe. Left arm fucked." Tim tried to pull Joe through the slot, grasping his right arm. Joe yelled in pain, and Tim asked if that arm hurt as well. "Everything hurts. Do it anyway." With that, he pulled Joe and ordered him to kick if he could. He did, and he eventually came out of the slot and slid down onto the top of the muddy ramp. There is a very uneven ledge at the top of the ramp that is barely large enough to sit on. It is not possible to lie prone, but Tim reasoned that this was the best place to attend to Joe's injuries. The only other alternative was to pass him the three or so meters through the slot and immediately rappel to the bottom of the wall. Joe was loudly complaining that breathing was difficult, so Tim focused on that problem first.

## ACCIDENT SCENE 0-9 WELL CAVE



The primary reason Joe seemed to be having trouble breathing was that his seat harness had ridden up onto his chest. This was a butt-strap type of harness without leg loops. Normally this type of harness (similar to the Petzl Rapide) utilizes an additional strap that goes between the legs, around the butt strap, and comes back through the legs to fasten to a buckle on the harness. Joe had deleted this strap from his own harness when he

made it.

Tim was wary of removing Joe's harness since Joe was in danger of falling off the ledge, but he needed to breathe. As it turned out, Tim could not have cut it off in any case as he couldn't find Joe's knife. Joe was still somewhat lodged in the lower recess of the slot, so the gear hanging from his harness, including the knife, was obscured. The angle of the ramp was too steep to allow him to pull Joe up onto the small ledge. Time was short, so Tim decided to get him off the wall altogether, but noticed that there was weight on the rope below him.

Even worse, from where he had down climbed the rope had rested on two rocks jammed into the top of the slot. These rocks were holding the weight of the climber on the rope. He repeatedly pleaded for the climber to get off of the rope, but she replied that she couldn't. Sarah was not familiar with the process of changing over to rappel while on rope. Tim then told her to just keep climbing up, as he reasoned that he couldn't describe how to do a changeover successfully. He then left Joe and climbed the three meters to get out of the slot. Once above, he could meet Sarah and let her change over to his part of the rope. This proved impossible, as the rope was deeply jammed within the chock stones and it kept Sarah from climbing to him. Instead, he pulled her through a wide part in the slot below the chock stones and Sarah eventually got onto the small ledge behind him.

Once there, he had Sarah attach herself to the rope above Joe with her cow's tail. By this time, Joe had lost consciousness but still seemed to be breathing sporadically. Sarah and Tim again tried to move Joe to the ledge so they could take his weight off of the harness and allow him to breathe, but Joe's body was covered with slick mud and the only place to grab him was his harness. Tim managed to stem the sides of the small ledge and pulled Joe up several times with his legs alone. This only worked for a time to relieve some weight from Joe's harness, but he would again slip down into a lower position in the slot.

Once again, Tim made preparations to get Joe off of the wall entirely instead of continuing the futile effort to get him onto the small ledge. The rope needed to be removed from the chockstones and passed through the back of the slot and down the ramp. He did that, and then rappelled below Joe and clipped him into his cow's tail with two carabiners. By now it seemed painfully obvious that Joe was not breathing. It would have been very difficult to administer CPR in Joe's awkward position, and so they didn't attempt it. Sarah is an EMT, and she confirmed that Joe had no pulse and was not breathing.

Regardless of Joe's condition, they were committed to getting him down at this point. Once on the ground, CPR could be given easily. Since the slot was very tight, it was difficult for Tim to see his micro rack, much less manipulate it effectively. He knew that he wanted it locked off when he took on Joe's full weight. He had to guide Joe down the muddy ramp, frequently pulling his legs out from under him and getting him unstuck.

Eventually, Joe slid out and onto Tim's cow's tail. Tim then rappelled with Joe to the base of the wall. The rack held both cavers' weight well, and the rappel felt safe. When Tim got to the bottom, he got Joe to a somewhat flat area and quickly looked for a knife to cut his harness off. Charley Savvas and Frank Delgado appeared at that moment and came to assist. Tim knew that Joe was probably dead, but said that he was trying to get his harness off and needed a knife. Charley produced one, and they moved Joe to a better spot and

cut off his harness and cow's tail. Frank, also an EMT, examined Joe and concluded that he was dead. CPR was briefly given, but it was too late to matter.

## The Recovery

Other cavers arrived from the surface with a SKED litter and other rescue gear, and the body was packaged for hauling. Patrick Lynott directed the rigging of haul systems that were used not only on drops but also in the canal areas. They moved the body up four rope drops to the bottom of the second drop, then left the cave to get some rest at around 0300 on the morning of 1 October.

Calls for assistance had gone out to cavers in central Texas at around 2300 on 30 September, and cavers began arriving at the site before dawn the next day. Law enforcement authorities had been notified during the night, they had visited the site and closed the entrance with police tape to keep anyone from re-entering the cave until the Justice of the Peace arrived in the morning.

After clearance was received from the authorities, trained cave rescue personnel led by John Green, South Central Regional Coordinator of the National Cave Rescue Commission went in to finish the recovery just after 1200. Besides John, these were Tim Comer, James Davis, Rod Dennison, Tommy Gillis, and Monty Strange. Rebecca Jones and Patrick Lynott rigged the entrance pit. Joe's body reached the surface at 1610.

## Review



, Peter Sprouse, and Kevin Stafford entered the equipment from the lead climb, and de-rig the cave. They found much of Joe's gear lying on the floor and in muddy pools.

While Kevin and Andy gathered gear, Peter took photos, and Carlos climbed up the bottom fixed line up the dome to have a look at the ledge area where Joe landed.

From Tim's description they knew this rope was tied to two bolts that had not been affected by the fall. The rope passed up a narrow crack to the steep, muddy slope. The rope went up over a rounded hump to the side, and was fixed to two bolts about eight meters above the mud ledge. From that point, a smaller diameter rope went straight up out of sight. The bottom end of

it was tied to one of the two anchors, the top end was presumably attached to the two bolts that formed the belay point that Joe was using. The Slyde was not present at the bottom. Carlos tugged on it, and it felt solid, but at that time there wasn't any assurance that this rope would be safe to climb.



On 2 October, John Fogarty, John Green, Rebecca Jones, Missy Lynott, Patrick Lynott, Carlos Nasby, Charley Savvas, Jessica Snider, Peter Sprouse, Kevin Stafford, and Tim Stich met to analyze the gear that had been retrieved from the base of the climb.

### **Items Damaged in the Fall**

1. The frog chest loop was cut at the point where it went through the Croll.
2. The belay rope was cut in two, half of which was recovered, the other half is presumably at the top of the climb.

Unfortunately the Croll was not found. This seems to have been lost in the mud as his body was being prepared for removal. No one specifically remembers removing it when the gear was removed from the body, but the body was covered with heavy mud at the time. It would be useful to inspect the Croll for fall damage or rope fibers.

The cut lead rope was immediately seen as the cause of the fatality. The damaged area on the rope had 80 cm of core exposed, though due to stress on the core the actual length of this section of core prior to the damage may have been less. The core was puffy, bundles separated, and there were lumps where it had melted. The sheath was shoved down the core and had noticeable compression for 90 cm. It is assumed that the Croll cut the rope under a catastrophic load.

## **Gear Selection and the Belay System**

Joe always looked for ways to improve caving techniques, and for this climb had developed a direct aid self-belay technique. In Joe's experience, more than one of his belayers on dome leads had fallen asleep or dropped him a long way during the many hours a climb typically takes. The climb in O-9 Well would have been especially dangerous to belay. The route corkscrews, making communication from top to bottom nearly impossible, and large chunks of mud were continuously knocked down to clean the wall for the drill. Self-belayed aid climbs are more common in outdoor rock climbing than caving.

One of components that Joe decided to use was the shock absorbing Kong Slyde. This device had worked in previous falls in the dome, however the performance of friction devices of this type is unpredictable due to variables such as water or mud on the rope, orientation of the device at the time of loading, and friction added by pieces of protection and rock rub above the belay.

Joe also used a seat harness that did not employ individual leg loops, but rather was made up of two sewn webbing bands: a waist belt and a butt strap. Joe had used this harness, without the crotch strap to hold the butt strap in place, without incident in many minor falls. With the severe shock load, the butt strap came out of position and the entire harness rode up around his chest. This could also have had serious consequences had the rope not broken and left him hanging.

## **Possible Scenarios**

Joe climbed the second standing line and moved the self-belay setup to the highest two-bolt anchor. In the 30-45 minutes between the beginning of his ascent and his fall, he would have been able to drill and set a maximum of two pieces of pro. At the time of the accident, Joe's hammer was on his seat harness in the carabiner that held it, and his hammer drill was in its pack, which Joe used like a holster to keep mud off of it.

Joe was alone when he fell, and no one knows exactly what he was doing at that moment. This scenario is speculative, based on the evidence currently available. If and when it is possible to inspect the actual fall site, a more accurate account may be possible.

It is believed that Joe set one piece, probably a 3/8 inch RB. Joe had set the RBs in between bolts on the previous pitch, so it is likely that he continued the practice. Following the steps, he would have put a carabiner with etriers on the RB, and stood up to pass a loop of slack from the lead rope into the carabiner. He would have ascended to the RB, put his fifi hook into it, and then readjusted and stood in the etriers. He may have drilled a second hole, put a bolt in with a hanger and carabiner, and again thumbed his Croll to get slack in the rope.

At some point during this process, the RB that Joe was hanging on pulled out, and he fell with very little rope out. This would result in a short fall that approached fall factor of 2.

As Joe reached the end of his rope and began to decelerate, the first thing to fail was the chest harness, which cut at its attachment point to the Croll. (The chest harness in the Frog system is not a life support component by design.) Joe's hips then slipped through his seat harness, which rode all the way up to his chest. There is no way of knowing how much cord, if any, traveled through the Slyde, since the rigging at the top has not been inspected. The few meters of damp 9mm static rope may have stretched as much as 10%. However, not enough energy was dissipated in these events, so the remaining force caused the cam on the Croll to cut the lead rope. Joe then fell free for 12 to 18 meters.

### **Fatal Flaws in this Belay System**

- *The main problem with the belay system was connecting the climber to the rope with an ascender. Ascenders are designed for ascending, not belaying. Petzl's loading figures indicate that the Croll will cut a 9mm static rope at 4kN (a moderate fall).*

Although Joe was aware of this data, he did not believe the failure mode of the Croll with the rope diameter he selected would be the complete cutting of the rope. Joe had expressed to Tim that he believed that the rope sheath would be ripped and bunched while the Croll slid down core. Joe had several experiences where a Petzl ascender had cut a sheath in this manner, most dramatically when shock-loading an 8:1 haul system. The core was puffy and separated, but held. In this case, the load was removed after the sheath failed. The force in a fall will continue until expended in other ways.

- *Using a static rope for a leader belay, where high fall factors are by definition expected, is dangerous, even with the addition of energy absorbing devices. The lead rope Joe and Tim used was 9mm static line. In standard lead climbing practice, the stretch in dynamic rope absorbs most of the force of a fall. The Slyde, whether because of its inherent functional limits or because of the method of application, was not able to absorb sufficient energy. The choice of static rope comprises one of the miscalculations made in the design of this belay system.*

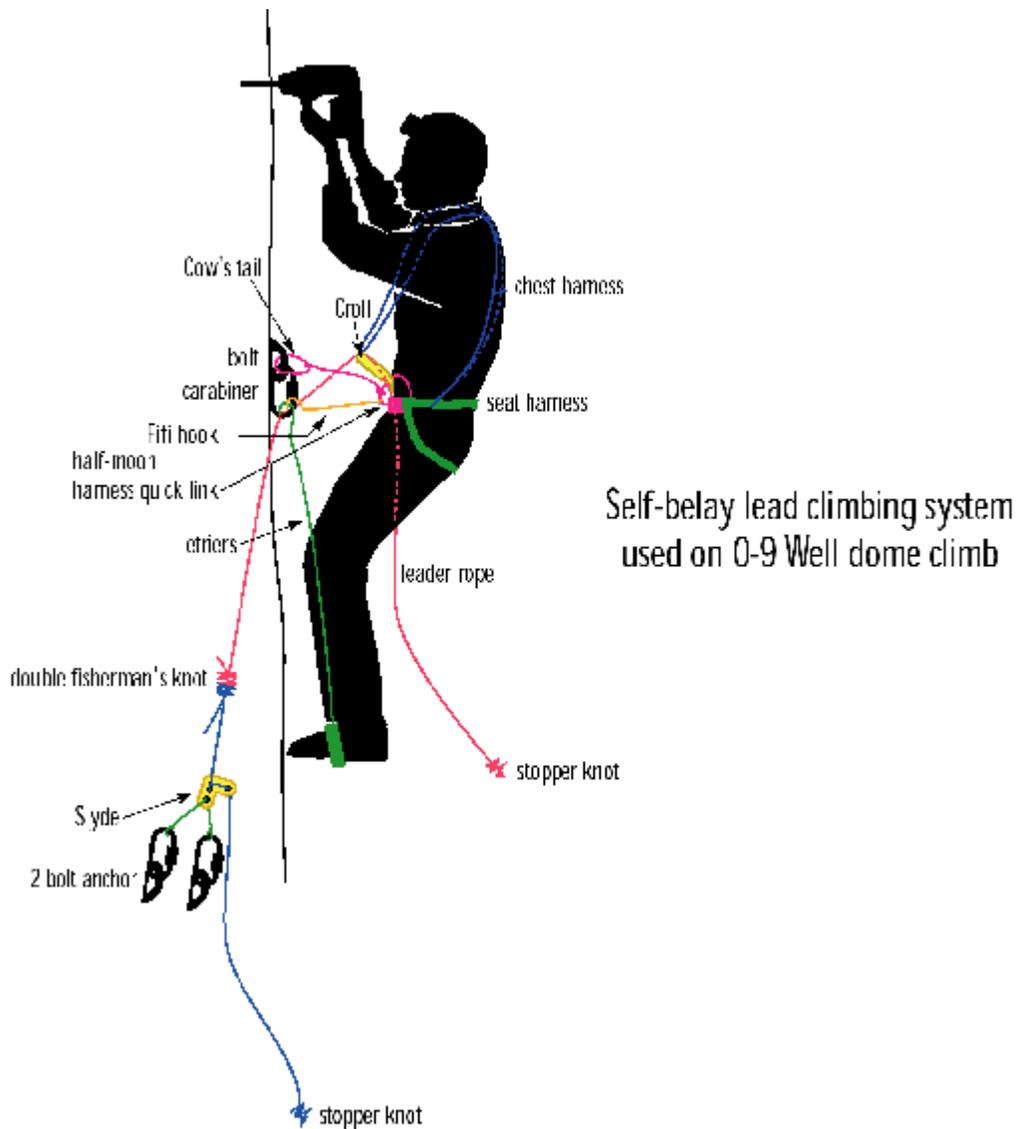
Factor 2 falls put tremendous strain on equipment and climber, and should be avoided if possible. In lead climbing, the beginning of the pitch can be the most dangerous because the potential of a factor 2 fall is greatest. When beginning a dynamic climb, it is essential to put in the first pieces soon, and make them bombproof. Although counterintuitive at first glance, short falls can in fact be the most dangerous. [In rigging fixed ropes for caving, where there is no energy-absorbing mechanism, it is essential to design and rig anchors to minimize potential fall factors.]

Testing conducted by Petzl shows that a factor 2 fall on dynamic rope will generate a force of 9 kilonewtons (kN), assuming a typical climber weight of 80 kilograms. [A kN is the force which gives to a mass of 1000 kilograms an acceleration of 1 meter per second squared.] Joe weighed more than 110 kg with his gear, which would increase that load to 13 kN. A paper by Bill Storage and John Ganter suggests that these forces may be MORE than doubled by the use of static rope, bringing the impact force to greater than 26kN.

## Performance of RBs in Caving Conditions

The problem with placing RBs during this dome climb was that they performed erratically in the cave. It was nearly impossible to keep them clean before inserting them in the drill holes. Muddy hands, random patches on clothing, and the mud and water covering the cave wall made contamination almost assured. The hardness of the limestone varied, as is common in caves, and the integrity of the rock affects how well an RB will hold. Wallowing out the hole with the drill also negatively affects RB performance. RBs were, however, quick to place and did hold in many cases without trouble. One 3/8 inch RB placed in an overhang caught Tim's fall, which attests to the device's potential performance. Overall, the small time and weight savings in using RBs is questionable, given their unreliability in cave rock. It takes only a few more minutes to install a bolt.

Joe and Tim used Climb Tech Removable Bolts and they each fell when these pulled out. In every fall, they had the benefit of several pieces of protection prior to the RB placement, thereby reducing the fall factor. Tim found the fall he took to be fairly soft, he was able to immediately continue bolting and was not unduly shaken by the experience. Joe was similarly unconcerned about the force of his own two falls and did not see a need to redesign his belay system to handle more energy. Both Joe and Tim stopped using the 1/4 inch variety after the first trip, and by the last trip, Tim had quit using RBs altogether, though he blamed their failure on mud and water contamination of the holes. - *Through their experiences of falling, they became wary of the performance of the RBs, but developed more trust in the belay system.*



## Lessons Learned

A mechanical ascender should never be used as a primary part of a belaying system, no matter how many subsequent devices are added to absorb the energy of falls.

Static rope is unacceptable in a belay system. Dynamic rope of 10mm or larger diameter should always be used for belaying leader climbs.

Removable bolts, if used at all in caves, should be used with extreme caution, as they perform poorly under wet and muddy conditions.

## **Conclusion**

The fact that some falls of lesser force had occurred before the accident led the climbers to feel that the belay system was adequate, however these falls were too few to actually validate the technique. Planning an ascender belay that was believed would "only" result in the stripping of the rope sheath was poor judgment from the start. Joe's death was due to his own actions and the judgments he made in designing and applying his belaying system. No piece of gear failed in a way that was not known to happen. The belay system design was perilously flawed in that it did not allow for the force of a factor 2 fall. A belay system should be designed to handle the maximum fall possible. The good performance of the belaying system on gentler falls helped foster a sense of complacency in the climbers. Overconfidence kept them from continually questioning their system and methods.

**All illustrations by Tim Stich**

**For the complete accident report, details of the recovery, and all related links, see [www.texasroperescue.com/0-9/](http://www.texasroperescue.com/0-9/)**

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