Ecological 4 WHEELING ADVENTURES

Newsletter Reprint, rev3 Recovery *Committed to Ecological Backcountry Travel* ***Since 1984***

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NEWSLETTER REPRINT

RECOVERY

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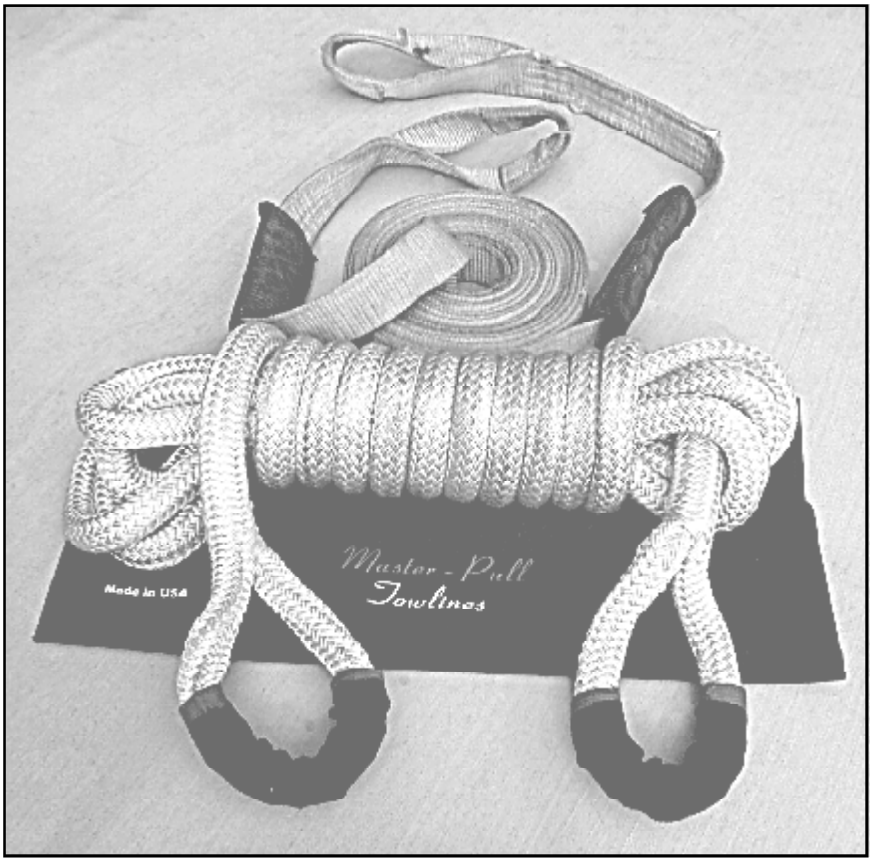
FOURWHEELING ACADEMY

YANKERS AWAY



Old yellow yankers away (top); in with the new Master-Pull round towline.
Photo by Harry Lewellyn

By Harry Lewellyn

We should all carry one. I feel naked without mine. The only thing I took on my Costa Rica adventure was one. Whips and chains and cables and ropes and straps all work, but some of these things are better than others. I used to call my tow rope recommendation a yank strap. However, something new has just hit the market. Now there's a choice. It's made from round rope, not flat, yellow strap stock. Let it be known, "yanker" is what I'll call my preferred tugger from now on.

I use yankers to tug and tow one vehicle with another. The common denominator is what they are made from. Nylon is the key to their effectiveness, and also the source of concern and danger.

This is the first of several articles on yankers and their use. What follows will introduce the new guy on the block — the Master Pull Towline. In the November-December issue, I'll address using them. The final article will reveal a subtlety or two with regard to handling and storing all kinds of rope-like things.

WHAT TO BUY

Don't fall prey to the "Great American Big Numbers Misconception"; i.e., bigger is better. Buy something that will work for you. Don't go for big numbers that you can brag about. Go for what's practical for your size vehicle.

For most SUVs, I recommend your yanker be 20 to 30 feet long and rated at 20,000 to 30,000 pounds (strong). Much weaker and you'll break it. I've got a garage full of failed 20,000-pounders. Too much stronger and they have less of the elastic quality you'll learn to depend upon.

It must have loops at both ends, not hooks. Hooks, if dislodged, can become lethal projectiles (cannonballs). There will be more on the dangers and safety of yankers next issue. On the traditional flat yank strap, I like the loops that are reinforced by doubling over existing material. The ones that have an extra reinforcing piece sewn in the loop are stiffer and more difficult to place in a tow hook, particularly the hooks with a mouse. More on mousin' around next issue. The round rope design I'm reviewing for this article uses a short tube of braided nylon to protect the loops (see above picture).

The common denominator, short or long, strong or weak, flat or round, is *nylon*. Nylon has a stretchy quality that

allows a 30-foot strap to lengthen considerably and not yield so much as an ounce of strength. It's this elastic quality that we'll learn to take advantage of when really stuck. Other materials like hemp, cotton, polypropylene and polyethylene weaken when stretched. Typically, these readily available highway devices are shorter (six to 12 feet long) and have a hook at each end. Avoid them like the plague! You'll hurt someone or something if you don't. They are easy to misuse in serious unpaved applications.

ROUND ROPE

For a couple of reasons that will follow, for years, I've suspected round rope would make better yankers than flat strap. The photo (above) is of one of my first attempts with a round, twisted nylon rope.

Ropes and knots fascinate me and what's pictured is a traditional work of art. The ends are whipped with string. The loop, or eye if you hail from the nautical world, is beautifully braided (spliced) to become one with the balance of the rope. The purpose of the black line tracer will be explained two issues from now. Walt Travers of Camarillo, Calif. made these.

Twisted rope and braided eye by Walt Travers
Photo by Harry Lewellyn

NEW DESIGN

Emil Bjornsson, founder of Master-Pull Towlines, makes a dream-yanker. His superior product is now on the shelf. The rich tradition of the sea permeates his skills and knowledge. He worked as an Icelandic fisherman for many, many years.

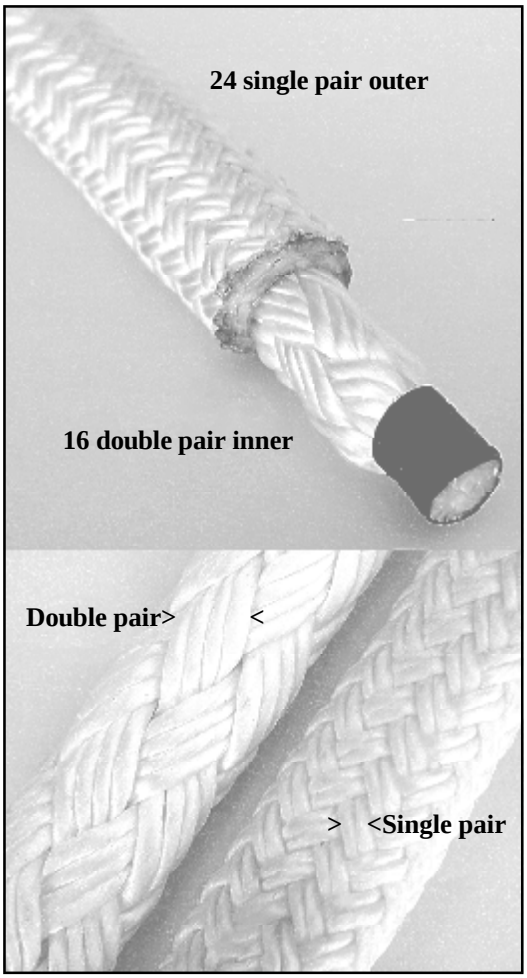
The Master-Pull product that's under scrutiny is a 30-foot long, 7/8-inch diameter, 28,500-pound, double-braid, round nylon rope yanker. It has reinforced, spliced eyes at both ends and comes in a handy carrying bag. I chose navy blue. It's available in black, red, woodland green or brown, and either jungle or desert camouflage.

Double braid means one rope within another (see photo left). Both inner and outer ropes are tube-like, only one fits within the other. The outer rope is made of 24 single twisted pairs and the inner rope of 16 double pairs. According to Emil, "The inner rope provides most of the strength. The outer rope adds a little strength, but is mostly for protection."

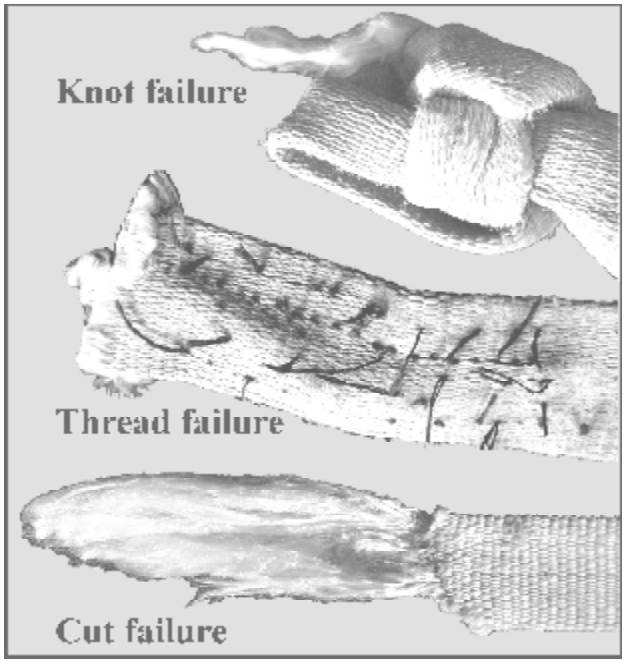
When first received, I thought the eyes were of the simple Chinese finger-trap design. Since I'd seen many highway-type polypropylene ropes use this questionable technique, I doubted the reliability, but soon learned how wrong I was. The eyes are manually spliced into his towline. See the sidebar on the next page for how that's done.

INSPECT YOUR STRAP

Half of my garage is full of broken flat straps and the other half with failed ones. Regardless of design, before each use, inspect your yanker. You can do most of this with your eyes closed. Really! It's easy! Simply glide your hand over the entire strap. Voids, fuzziness and irregularities are your clue to inspect closer.



Double braided rope
Photo by Harry Lewellyn



Flat strap failure modes *Photo by Harry Lewellyn*

Slipping your hand over a new yanker is reasonably safe, but be more cautious with used ones. Small embedded sticks and metal may draw blood before drawing your attention to their presence. I'll now open your eyes as to how yankers fail and

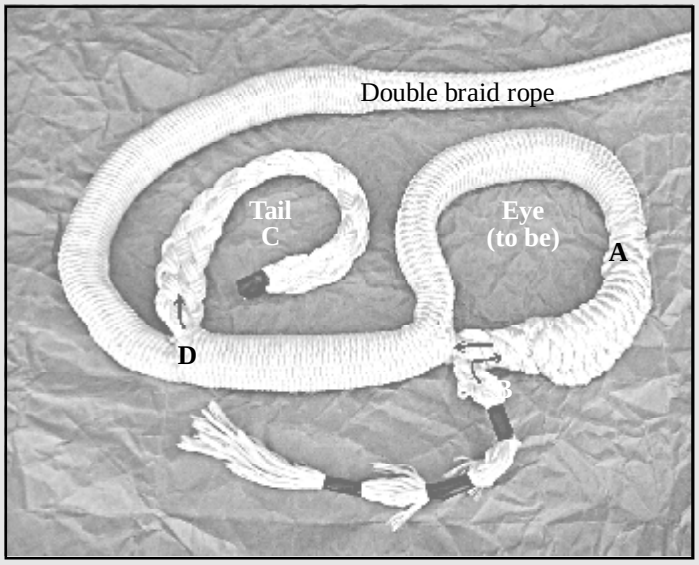
SPLICED EYES

Eye-splicing is extremely labor intensive. Not that you really need to know, I thought I'd give you the inside scoop on how they are made. Maybe it's more like the inside-out scoop.

Remember double braid means one rope within another. One of the first steps involves literally turning a length of the rope inside out. The inside is first removed from within the outside. The (real) outside is now fed back into and through the (real) inside. This crossover point (inside-outside swap point) is designated A in the photo. This figure shows an eye under partial construction. For ease of photography, there is no reinforcing tube shown on this eye.

The tail of the outer, now inner rope is then tapered by selectively cutting strands in a very specific manner. This tail eventually gets pulled entirely inside the real inside, now functional outside, to the right. That happens at point B.

The eye is then reduced in size by pulling the inside tail (C) out and up until the crossover point (A) is just inside the real outside at point D. With more specialized cutting and tapering, tail C is also made to disappear within. But you ain't done yet.



Double braid eye construction

Photo by Harry Lewellyn

Under tension, the eyes function impeccably. Under potential no-load mishandling, the eye could move, so a lock stitch (not shown) makes two passes through the entire rope at about point D. This insures the eyes stay put.

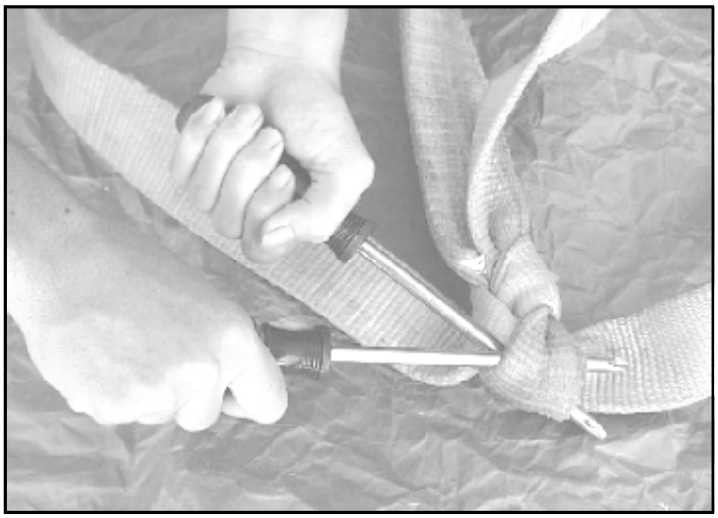
There are no machines that make this kind of eye-splice. The process takes special tools and skilled labor. Emil is very proud that he has not caved to the economies of offshore production. His product is totally America made, including the carrying bag.

let you know why the Master-Pull Towline is better.

FAILURE MODES

I have experienced four yank strap failure modes. One has to do with the thread that is used to sew the loop into a flat strap. Another is related to knots in flat straps and the most common is due to contact with hot or sharp things on either the tower or towee. The last is simply overstress misuse, which I'll address next issue.

I'm disappointed some loops are sewn with cotton thread. I prefer synthetic materials to natural threads in this application. Once wet, cotton thread seems to weaken; hence, the loop becomes less reliable. I think it has to do with shrinkage, just like in our blue jeans. Loops that have been wet, but now even dry, are weaker than loops that have never been wet.



Untying flat strap knots is tough!

Photo by Harry Lewellyn

As you'll read shortly, knots reduce the strength of what they are tied in.

What crops up again and again are cuts and burns. Here, the yanker touches something on the 4X that does damage. Sharp metal edges are everywhere and exhaust components can easily exceed 505°F, the nylon melting point. And unfortunately, more often than not, the damage is only partial, not total. With total failure, you can't use it. With partial failure, we're inclined to dangerously "give it a try," anyway. Here's what I do to prevent this common malady.

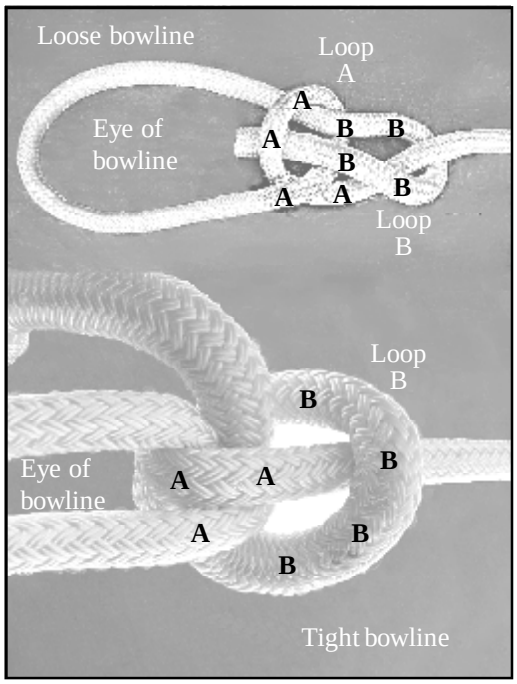
YANKER PROTECTORS

Sharp and hot things under the 4X can cut and damage yankers. A damaged strap or rope is weaker and thereby more dangerous. I've got a way to prevent that.

I have two pieces of lower radiator hose that are threaded onto my yanker. These are visible on my flat yank strap in the first photo. After the attach-loop is in place, and before I leave the installation, I inspect for potential yanker burn

and cut contact points. When found, I simply slide the yanker-protector hose into place and tape it down. The sharp or hot metal now gnaws away at only the protective hose, not the vulnerable yanker.

I use lower radiator hose because it is typically tougher than upper hose. The lower hose is on the suck side of the water pump and must be stronger to prevent collapse when hot. Go for a hose that has built-in reinforcing wire.



Loop B always stays loose for untying.
Photo by Harry Lewellyn

STRAP LENGTH

My yanker is always the wrong length. It puts the tow vehicle right in a ditch, up a hill or just around a corner. I like to be directly ahead of or behind, on level ground. With flat yank straps, to make 'em shorter with knots takes caution and some skill. I'll cover makin' 'em longer in the next article.

KNOTS WEAKEN ROPE

Be aware the rope books tell us knots weaken the material they are tied in, regardless of flat or round. As a rough rule of thumb, figure a knot is only half as strong as the base material. The books I have say a bowline weakens a rope by 35%.

The literature goes further and says, do not tie knots in flat straps. I have one flat strap that broke right at my bowline (see photo on p.3). I suspect knotted flat stock is even weaker than knotted round rope.

NAUGHTY KNOTS

The typical, flat, yellow yank strap is a naughty, knotty nightmare. With the massive forces that are characteristic of serious, *get'em unstuck* yanks, the strap stretches, the knot tightens, never again to be untied. I think I could drive nails with some of the knots I've put in flat yank straps.

The only way I've found to untie tight, flat strap knots is with two screwdrivers. With hammer, I first drive one Phillips through the knot, without cutting or stretching the fibers. Then I pound another along side. Finally, with continuous back and forth action, I loosen the knot until I can finish untying it by hand (see photo p.4).

NICE KNOTS

Master-Pull products are more knot-friendly and make knotted length adjustment a simple pleasure. Use knots known to be easy to untie after tensioning, like a bowline. Simply tie the loop where needed and stow the balance safely out of the way. Excess can temporarily be thrown in the SUV through the back window. The real macho way to do it is "figure eight" it around the front bumper.

The figure shows a bowline in construction and another under tension. The essence of a bowline is that loop A tightens on the eye and loose end of the line while loop B remains loose. The bright white in loop B on the tight bowline clearly shows it is still loose. When relaxed, loop B is easily bent over the loose line and then untied, all by hand.

TUG TEST

My poor ol' magnolia tree bore the brunt of my tug attack. To be fair, I looped a flat strap in series with the round one and yanked away. With this configuration, both received equal pull. There was no way one got tugged more or less than the other.

Both were identically strained, neither broke, and the results were mostly as expected. The bowline in the Master-Pull untied easily and the flat strap required the screwdriver treatment. What surprised me was that the flat-to-round, interface "knot" was reasonably difficult to untie, too. You'd expect that a light push would untie a "loop-through-loop" attachment knot. But the flat stock mischievously resisted separation. Naughty knot or not, I primarily wanted to test stretch factor.

Again, Master-Pull revealed its superiority. It stretched easier. This means it will feel gentler when you really give 'em hell in a serious yank!

The flat strap material is more tightly woven than its round relative, and hence elongates less. Less give means immediate and more intense yanks. When you need momentum to get unstuck, more elasticity works better. Round is gentler.

The unstressed round strap measured exactly 30 feet long. The traditional flat strap was 29 feet, 6 inches long at rest. When stretched, round went to 34 feet, 4 inches while the flat guy only went to 30 feet, even. Longer means easier! That's 14+% stretch for Master-Pull and only 1.7% for the traditional flat yellow strap.

ADVANTAGE ROUND

Master-Pull round towlines have three distinct advantages. Primarily, they can be easily knotted and unknotted by hand. That alone is enough for me to use it. Two, the eyes are spliced vs. sewn into the base material. No additional thread is used to make the eye. This all but eliminates this annoying failure mode. Third, the net (elastic, nondestructive) stretch is greater, which results in more gentle yanks. I also like the way a round rope stores vs. flat stock.

For the next several months, I'm offering the 30-foot, 28,500-pound Master-Pull Towline with storage bag for sale. It's a bargain. I pay tax and shipping. See our newsletter to order.

NEXT MONTH

Next month I'll attack the process of towing and tugging. We'll learn how to hookem up, what to connect to, DOT holes, the "Coyote chain," mousing the hook, yokin'em up, pullin'em clear back to camp and about the cautions and dangers associated with towin' and tuggin'.

FOURWHEELING ACADEMY

By Harry Lewellyn

TOWING BASICS

INTRODUCTION

Let there be no doubt: Towing and tugging one vehicle with another can be dangerous. In your well-meaning attempt to help, you may do serious harm. And that should come as no surprise when you consider the size, weight, horsepower and rock-throwing tires of the vehicles we take off-road. It is easier than you think to break parts and injure people when towing and tugging.

What I also believe contributes to the mayhem and chaos of towing and tugging is our state of mind. No one likes to get stuck, but it happens to the best of us. It's embarrassing, it delays our progress and could be life- and equipment-threatening in certain situations. As Hurricane Floyd clearly demonstrated, raging waters spare nothing, but that's still no excuse to work unsafely. My intention is to help you safely improve your results on both ends of the towline. Safety will be laced throughout this article. Do not take it lightly!

I'll first fill you in on where and how to hook up. Then I'll address towing. In the follow-up article (January-February 2000), TUGGING BASICS, I'll zero in on the most dangerous process of all — an all out, serious, getem unstuck yank!

Diagonal teeter-totter disables my old Cherokee. *Photo by Harry Lewellyn*

ATTACH POINTS

This really happened. I'm working sweep on a ranger-led tour. Ranger passes stuck car and radios me to assist the stranded 2WD. The 4X just ahead is eager to help and offers his new yanker and labor. I hook up my end and he does the other. For this mild, flat sandy pull, I take out the slack, begin to tug, and hear a slight "plink" from behind. Upon inspection, I discovered the helper had attached to the car's license plate bracket!

Some folks have no sense of material strength. You are most likely more aware than that, but how much? Another example drives home my point!

Man and CJ stuck in mud. Unstuck friend attaches to one side of front axle and yanks with great vigor. Displaced front axle now relocated nearer to front bumper. Man and CJ still stuck in mud!

ATTACH RULES

Here are the Coyote's rules of attachment. If your candidate connection is designed to move, or is attached with rubber, ***do not use it!*** This eliminates shocks, sway bars, tie-rods, pitman arms, axles, radiators, springs, shackles, A-arms, drive shafts, tail pipes, motor mounts and too many other items to mention. Even modern shock-absorbing bumpers can be worthless. They are designed for push, not pull.

I've got to agree the front axle seems like a pretty substantial piece of hardware, but it moves *and* has rubber at the shackles. With this no-move, no-rubber thing, I'm trying to steer you to only use the frame or things directly attached to the frame. The forces involved in a full-on, all-out yank are massive.

Things that are attached to the frame may be questionable, too. Some dressemup foo-foo stuff is not designed for serious service even though it has been decorated with the appropriate hardware. I've seen hooks atop a ¼-inch steel "pretty piece" (brush guard) mangled and bent beyond recognition when used for a hefty tug. This has to do with the added distance and angle from the actual frame. The leverage kinda multiplies the force and twists 'em right outa whack! If you anticipate a serious, hard pull, connect directly and only to the frame.

FRAME ATTACHMENT

Tow hooks directly attached to the frame are best. However, some ask whether to bolt or weld them on. I prefer to bolt them on. I'm fearful welding will destroy the frame's heat-treating or be weak right at the weld. The average person doing the welding has never been educated about the "heat-affected" zone. That is a region, in

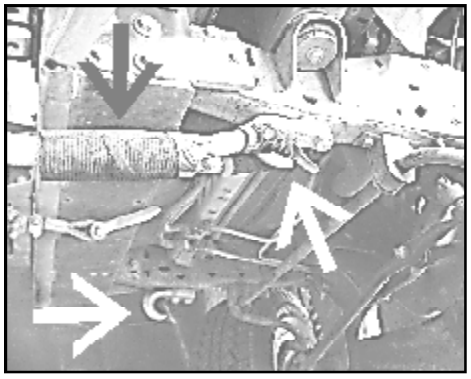


Figure 1 *Hooks bolted to frame with hose-protected Towline taped in place. Photo by Lewellyn*

the process of welding, between cold and hot metal, that crystallizes and becomes very brittle — weak. It's unavoidable

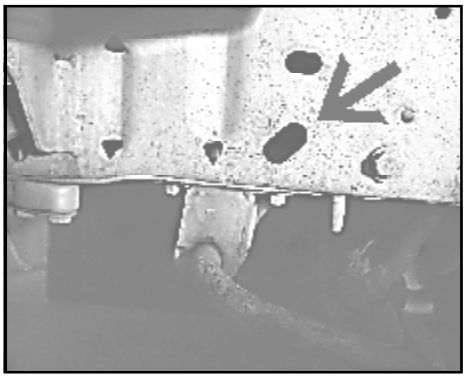


Figure 2 *Front D-hole near sway-bar Photo by Lewellyn*

without special attention to the immediate cooling process during welding. Figure 1 (page 6) shows two tow hook bolted to my Explorer frame.

Also, do you have a conventional frame or is it integrated with the body? Integrated frames are typically made from thinner material and thereby weaker. I've seen a Cherokee factory front hook bend and distort the frame. This is due to the integrated (thinner) frame and the fact that the factory hook adds about a one-inch extension to the attach bolts. This adds a "lever" to the pull-force and can bend the frame.

The intersection of the frame and a crosspiece may be another good attach-point. However, this assumes you're right at the corner and the crosspiece is made from approximately the same thickness of steel as the frame. Be aware there are front crosspieces that are little more than dust shields and are very weak. I've seen some made of pressed cardboard!

DOT HOLES

The U.S. Department of Transportation (DOT) ensures there be four frame attach points on every vehicle sold in the USA. The DOT requires a car-carrier hole be located near each tire. I call them dinosaur- or D-holes because car carriers are called dinosaurs. These are elongated holes. They are designed to receive special attachment hardware or a chain slip hook. They are typically in a vertical surface (Figure 2), but may be in a horizontal frame member (Figure 3).

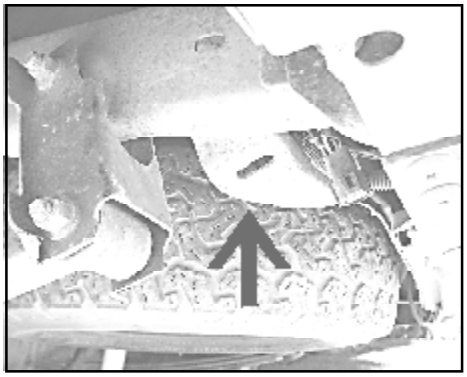


Figure 3 *Rear horizontal D-hole near spare tire. Photo by Lewellyn*

On 4WDs of the Land Rover variety, they are flat, vertical, egg-shaped pieces attached to the frame with a single bolt. These are definitely not suitable for serious tugging. Even if the bolt were strong enough for hard pulls, they would certainly distort and bend out of place. Avoid using these for all but the gentlest of tows.

The only problem with D-holes is that they are designed to pull mostly down — vertical — not horizontal. As a result, when you use them, you have to be aware of the added stress on the slip hook and what your chains, cables, straps and ropes will touch on their journey between vehicles. Typically, you have to either protect the yanker from sharp or hot 4X metal, or the 4X itself from yanker damage. Pay particular attention to the bumper, air dam and body as pictured in Figure 4. In this case, a hard pull will lift the chain and damage the air dam.

Figure 4 *Choke hook in vertical D-hole, but note potential air dam damage. Photo by Lewellyn*

YANK PROTECTORS

Sharp and hot things under the 4X can cut and burn yankers. Cuts and burns weaken the yanker and thereby make it more prone to break. Here's my preventative measure.

I have two pieces of lower radiator hose that are an integral part of my yanker. The yanker is threaded through both hoses (Figure 5). After the hook is in place, and before I leave the installation, I inspect for potential yanker cut and burn points. When found, I simply slide the yank-protector hose to the hazardous spot and tape it in place (Figure 1). The potentially dangerous interference now only gnaws away at the replaceable hose, not the vulnerable yanker.

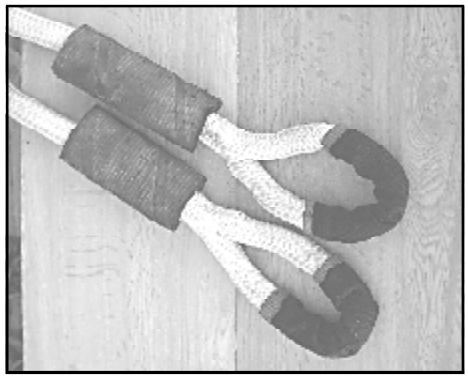


Figure 5 *Lower radiator hose "damage protectors" on towline. Photo by Lewellyn*

I use lower radiator hose because it is typically stronger than upper hose. The lower hose is on the suck side of the water pump and must be stronger to keep from collapsing when hot. Go for the ones that have built-in wire reinforcing.

TRAILER HITCH

I'm also reasonably comfortable with a class-III trailer hitch receiver for easy to moderate pulls. It's generally conceded that you stay completely away from using the ball itself. It's thought that if it breaks off, the projectile could be lethal. I agree.

Most yankers have eyes or loops at both ends that fit nicely into the 2-inch square hole. Simply push the eye into the hole, the retainer pin through the hitch and eye, and the two have become one (Figure 6 on p.7).

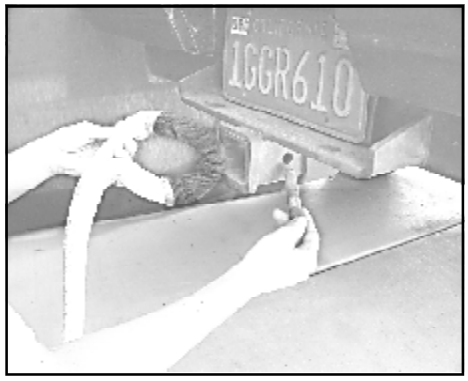


Figure 6 *Insert Towline eye into class III trailer hitch and pin. Photo by Lewellyn*

For even less aggressive pulls, I use

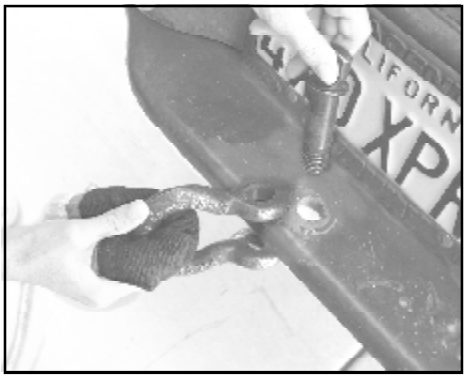


Figure 7. *Loop shackle through Towline eye and attach to trailer hitch ball hole.*
Photo by Lewellyn

the reinforced trailer hitch ball hole in my rear bumper. I loop a D-shackle through the eye in the towline and attach it to the bumper hole (Figure 7).

HOOK INSERT

Another trailer hitch product I've seen is a special insert that slips into the hitch receiver with a protruding hook. The *gozinta* part is just like a ball insert. It's made of heavy stock and uses the hitch-pin to lock it in place. Just outside the receiver is a conventional tow hook. I particularly like this because you can place the hook either up or down depending on the up-down hill direction of the pull. For relatively flat pulls, I think hook-up is best since it tends to keep the towline eye in place.

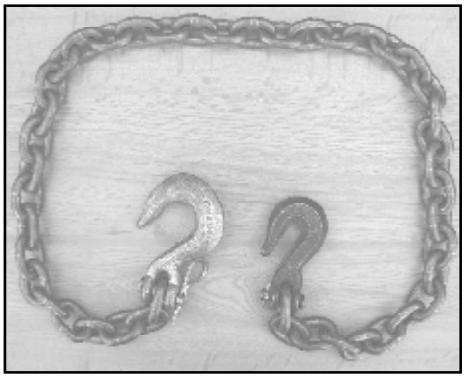


Figure 8. *Three-foot Coyote chain with choke hook on left and grab hook on right*
Photo by Lewellyn

COYOTE CHAIN

Nine times out of 10, I'm faced with a stuck newcomer that has no accessory hooks or loops on his 4WD. For this I've fabricated a special chain. Figure 8 shows a three-foot long chain that has a grab-hook (right) at one end and a choke- or slide-hook (left) at the other end. A grab-hook is designed to lock (grab) onto any chain link. The choke- or slide-hook has a more open end and easily slides up and down the chain. Typically, the grab-hook will not fit into a D-hole, but the choke-hook will, due to the more open nature of the throat.

(reprint corrected, see p.14) I secure the choke-hook to the frame in a D-hole (Figure 4, p.7). The chain then exits just beyond the nearest bumper. I feed the loose end through the yanker eye and lock the chain back onto itself with the grab-hook (Figures 9 & 10). Figure 9 is the CORRECT way to do it and figure 10 needs a few more words.

Figure 10 can pinch the line. Starting left, the chain goes through the towline eye, then back over and under the approach on the left and finally hooks onto the piece coming out of the eye, not the

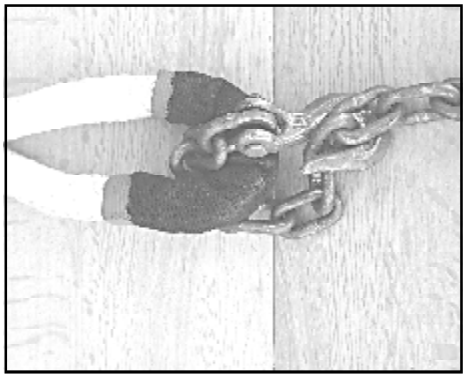


Figure 9. CORRECT! *A grab hook attached this way is best.*
Photo by Lewellyn

original approach section of the chain. In essence, this is a choker of a sort. This method may be useful if you need two chokers, but not good on the towline.

I actually carry two chains in case I have a newcomer on both ends of the tow

Figure 10. WRONG! *A grab hook attached this way stresses the line.*
Photo by Lewellyn

operation. The chain also doubles for repairs. When I broke my radius arm on a San Felipe, Baja trip, they were used to secure the lame front axle in place until I could get to a welder. See our newsletter to purchase a Coyote Chain.

MOUSE THE HOOK

You want to ensure that the towline's

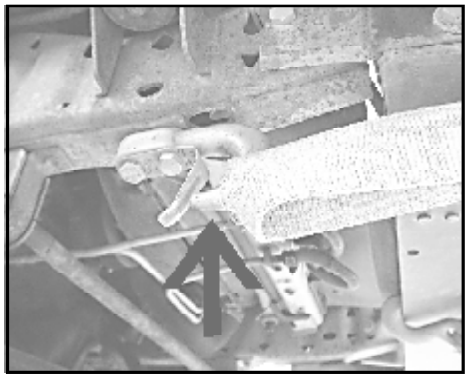


Figure 11. *Improperly or unmoused yanker can lead to strap damage!*
Photo by Lewellyn

attach-eye will stay in place on the hook. If the eye falls off, it's obviously no good, but simply annoying. Partially on (or off) is worse! The hook could pierce the yanker (Figure 11), reduce the strength and tear the line apart. Some hooks come with a spring mouse (Figure 1) that holds the Towline eye in place. With an open hook or any questionable attach point, use tape, a plastic tie or something to insure the eye stays in place. The mouse term comes from sailors and riggers.

READY THE YANKER

I'm getting a little ahead of myself with this and the next tip, but this one may help you stay a little cleaner. Even if you're not yet stuck, but see a lengthy stretch of muddy or wet, tough going ahead, do this. Attach and mouse the yanker to your 4X. Drape it out of the way back through a window or coil it on the hood (Figure 12, next page) or the roof rack. I've seen some folks wrap it around the bumper, but by the time you're stuck, the yanker may be under mud! Now, if you get stuck, you can climb out the window and toss the towline out to your pull without getting too dirty.

COLD CONCERN

In freezing cold weather, you may be faced with an unexpected surprise. You work your tail off to rescue your buddy. Come go-home time, you find your rope frozen stiff and impossible to fit back into

your 4WD. I find thawing and bending it around a warm (not too hot) tailpipe will get the inflexible, stubborn assistant back in the truck for further thawing.

YANKER LENGTH

As I wrote in *Yankers Away* (September/October issue), my yanker is always the wrong length. It typically puts the tow vehicle right in a ditch, up a hill or just around a corner. I'd like to be directly ahead of or behind my stranded companion, on level ground. To change the length of a flat strap takes extra caution and some skill. With a Master-Pull® round towline (see our newsletter to order), it's a cinch. Use a bowline in the round line to shorten it. Then, even after being stressed, it's no sweat to undo. The September-October issue also showed how to tie a bowline and the secret to untying flat straps.

For added length, you can resort to looping a couple of yankers together, but again, beware of the flat yellow yankers. Even something as elementary as a loop-through-loop in flat straps (Figure 13) can become impossibly permanent. It creates kind of a square knot. And never use a shackle to connect two yankers (Figure 14). If either yanker breaks, the massive metal shackle becomes a substantial cannonball!

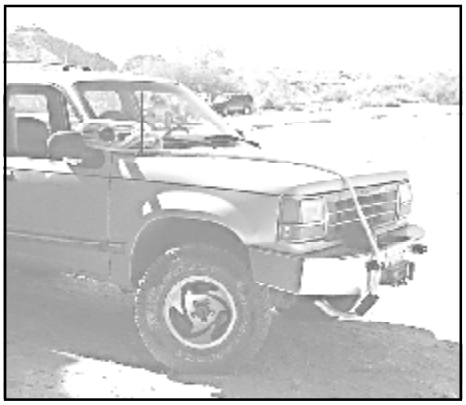


Figure 12. *Attached Towline, draped back on hood, ready for action!*
Photo by Lewellyn

YOKES

Ya *yokemup* to shorten 'em up. That's where you make the towline form a V. However, yoking up has its limitations and I only recommend it for towing, not tugging. Without fully explaining all of the reason, as the branch-legs of the yoke get shorter and shorter, the forces on the legs get greater and greater. It doesn't make sense to the nonengineer, but it has to do with the same principle as to why sailboats can sail into the wind. Beware of very short branch legs regardless of material.

TOW LENGTH

For tows back to camp, length is of even more concern. You're concerned with length for safety and functional reasons. Too short a yanker puts the towed vehicle dangerously close to the puller's tail. Puller may react faster than pullee

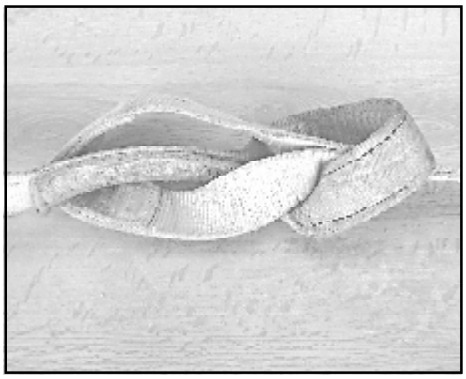


Figure 13. *Loop-through-loops can become permanent!* *Photo by Lewellyn*

and smash into his help. I have two short tales about too long a strap.

I'm towing broken Bronco on twisting Baja dirt road. As I round a tight corner, I slow, he slows slower, introduces slack, which he drives over and wraps around the inside of his front wheel. A fraction of a second later, the strap tightens and breaks the flexible hydraulic brake (fluid) hose. Not too cool! Malfunctioning brakes on the 4X behind are bad news, particularly for the guy ahead! Yanker was too long!

I'm towing broken Commanche around a mountainous hairpin turn. He does a better job with the slack and I pay less attention. The blasting horn tells me something is wrong. Picture we're on opposite sides of the hairpin turn, pointed in opposite directions, and I'm now dragging him sideways into the cavernous "no-road" center portion. Yanker was too long!

HOW TO TOW

For long tows like back to camp or on the road (when legal), the yanker must be safely long enough to accommodate reaction time, but not too long so as to introduce tracking errors. On the highway, too long may also entice unknowing others to pass and try to pull in between the two attached vehicles. By the way, it is illegal to use a towline on California freeways and interstates (CA Vehicle Code, section 29006a). The vehicles must be connected with a rigid tow bar. Know your state's laws before you learn the costly way.

The towee's responsibility is to keep the yanker taut at all times. Even the slightest amount of slack can get dangerously tangled in vital running gear. He does this by applying just the right amount of brake at just the right times.

The tower's responsibility is to make sure he doesn't drag the victim off the road on a tight turn as I almost did above. An extra person in each vehicle, with radio-mic in hand, adds instant feedback. Otherwise, both front and back vehicles should agree on specific hand signals prior to taking off.

When taking off, the towee should gently apply his brakes to ensure a taut towline. He should slightly drag the brakes for a 100 feet or so, or until rolling friction ensures he won't surge or coast ahead. With a stick shift, this means Mr. Towee should slightly apply his brakes during each shift, too.

To ensure that slowing and stopping does not introduce slack, it is the responsibility of the front vehicle to radio or signal back he's changing pace. The back vehicle must then slow or drag the front guy to a stop. On a downhill, this means the rear 4X drags his brakes to eliminate slack. To safely take off, shift, turn, slow down and stop perfectly is much harder

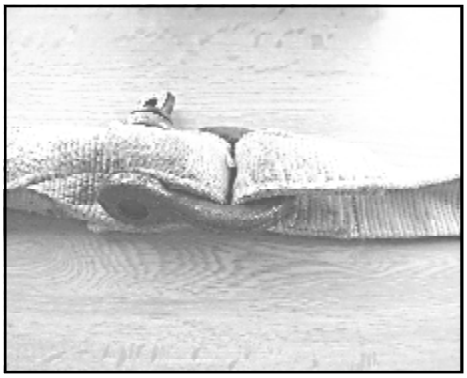


Figure 14. WRONG! *Never use a shackle (cannonball) to attach two yankers!* *Photo by Lewellyn*

than it may sound. But that's definitely less stressful and safer than *tuginum*.

TUGGING BASICS

Getting unstuck requires more preparation and serious attention to safety. TUGGING BASICS will be covered in the January/February 2000 issue of *Ecological 4Wheeling Adventures*.

FOURWHEELING ACADEMY

TUGGING BASICS

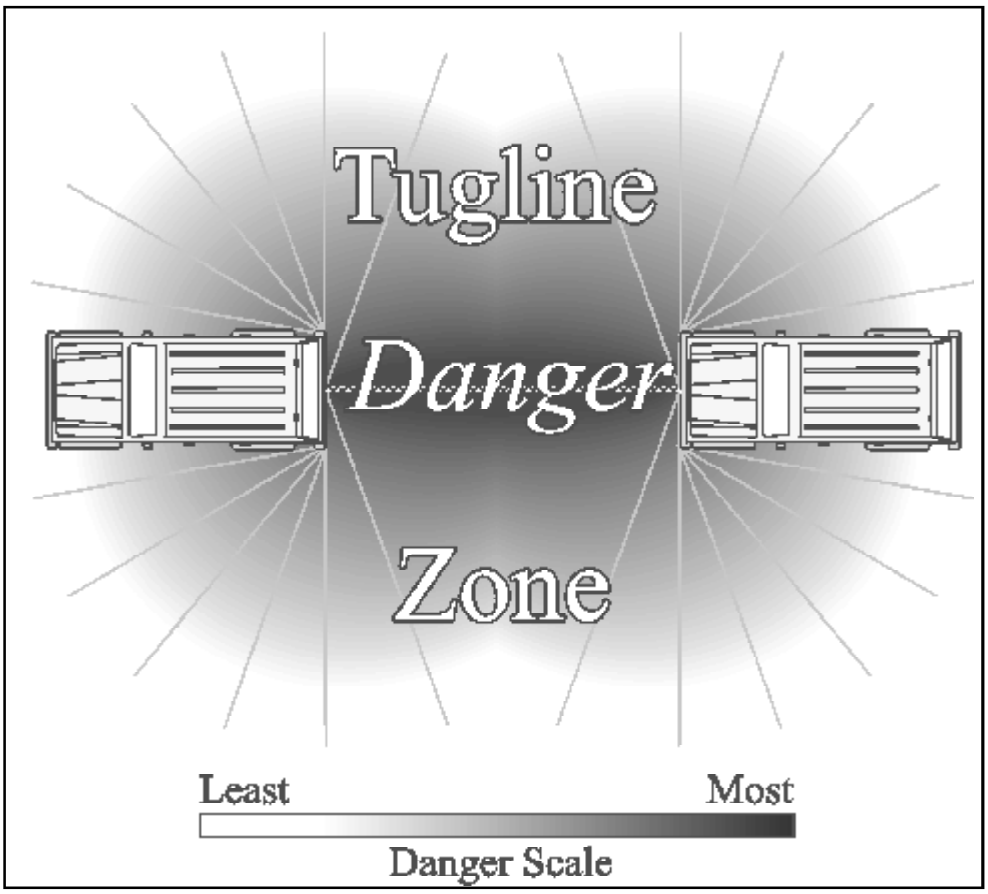


Figure 1 *Relative danger in the tug zone* *© Jan. 2000 by Harry Lewellyn*

By Harry Lewellyn

INTRODUCTION

Repeating from last month: "Let there be no doubt: Towing and tugging one vehicle with another can be dangerous. In your well-meaning attempt to help, you can do serious harm. And that should come as no surprise when you consider the size, weight, horsepower and rock-throwing tires on the vehicles we take off road. It is easier than you think to break parts and injure people when towing and tugging." Define, enforce and respect a *danger zone* encompassing the work area as shown in Figure 1 and explained in "Define the Danger Zone" on page 13. Tugging can be treacherous!

TREACHEROUS TUGGING

If towing is dangerous, then tugging is treacherous. It requires a crawl, walk, and then finally the deadly "run" approach, only when absolutely necessary. To start off running, with little or no experience, is irresponsible. This article builds on two previous *FOURWHEELING ACADEMIES* and in no way should be considered a stand-alone source for tugging. I make frequent reference to YANKERS AWAY (September-October '99) and TOWING BASICS (November-December '99). So let's first chill your spine with a few horror stories, hear how others helped me improve TOWING BASICS, then get on with how to tug.

HORROR STORIES

Tightly stretched things of any sort can be deadly … if they break or come loose! How about a few wakeup horror stories of unknown origin? There's the one about the strap with a metal hook that broke loose from its attach point. The hook came through the pickup's back window and killed the driver with a blow to the back of his head. Same story, but this time through the windshield, with a trailer ball, in the face! Different strap, spectator too close, strap cuts off legs. Another version except this time it's the onlooker's

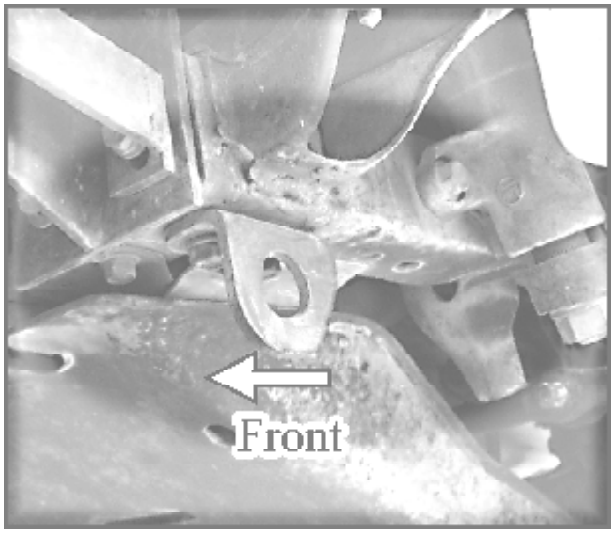


Figure 2 *Toyota "D-hole" front attach plate*
Photo by Harry Lewellyn

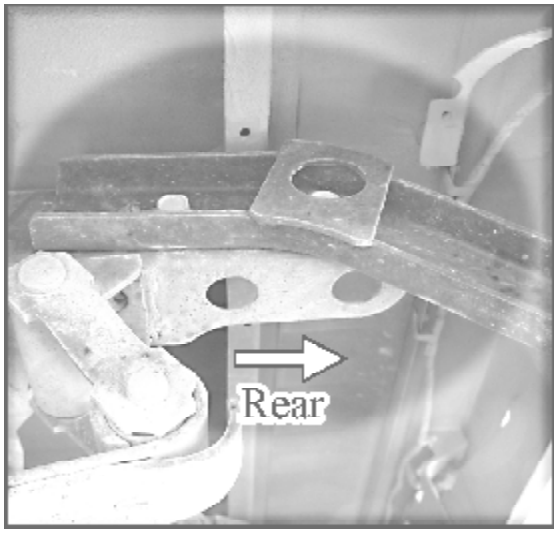


Figure 3 *Toyota "D-hole" rear attach plate*
Photo by Harry Lewellyn

head! Think of everything you use between two vehicles for towing or tugging as howitzer-size slingshots!

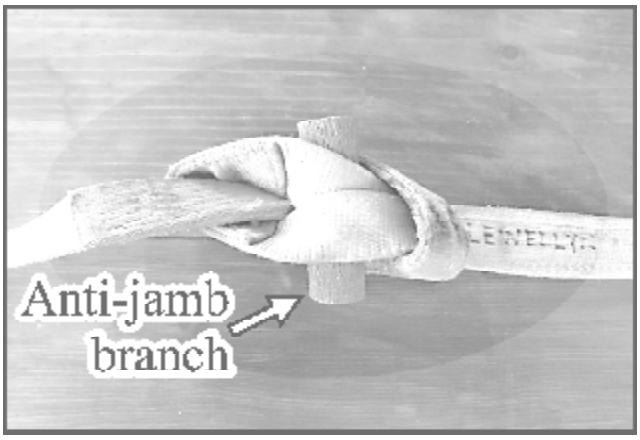


Figure 4 *Anti-jamb separator (untaped)*
Photo by Harry Lewellyn

Here's a true tale of what happened to my lumberjack uncle with just a ridged cable. His log-towing cable breaks, snaps forward and wraps and crushes him to the open seat of his Caterpillar. Several months in the hospital straightened out a couple of broken ribs, arm and damaged internal organs. Taut things of any sort can be deadly if they break or come loose! Don't take tugging loosely!

FEEDBACK

Fellow engineer Ken Obenski, P.E. (San Diego, CA) had several comments. I may have misled you when I said, regarding welding tow hooks to the frame, "… crystallizes and becomes very brittle — weak." He correctly points out all metals are crystalline structures and I should have more accurately said recrystallizes. He goes on to clarify that Department of Transportation holes are only required on vehicles that will be carried on car carriers. He owns "Big Mama," the 4X Chevy Van that towed me up from *Urique* Canyon in the Copper Canyon complex (see Bury my Ford in *Cerocahui*, January '98). Actually, it's wife Cindy's regular transportation. Since it's a 2WD to 4WD conversion, it lacks D-holes in the front. That may be due to the 4WD mod or that it was never designed to be hauled on a car carrier. Finally, he points out that a slip hook, when attached to a D-hole, puts the full stress on the hook. More on this later.

Myrna Wosk (La Jolla, CA) noticed her Toyota had another kind of "D-hole" attach plate. See Figures 2 and 3 for two variations that I would be skeptical to use for an all-out tug. I have no idea how many different "D-holes" there are in the world and would welcome your enlightenments. These will be used to continually update Web material.

"Loop-through-loops" drew comments from Frank Harris (Ramona, CA) and Jay Center (Mission Viejo, CA). Both suggested what I'll call an "anti-jamb" separator to join two flat strap loops. See Figure 4 and understand the last step would be to tape the anti-jamb in place (not shown). It would certainly simplify untying (have tested it) and I believe (never tested it) round material like a dowel or branch will stress the straps less than, say, a sharp-cornered 2x4 or other rectangular material. My only reservation

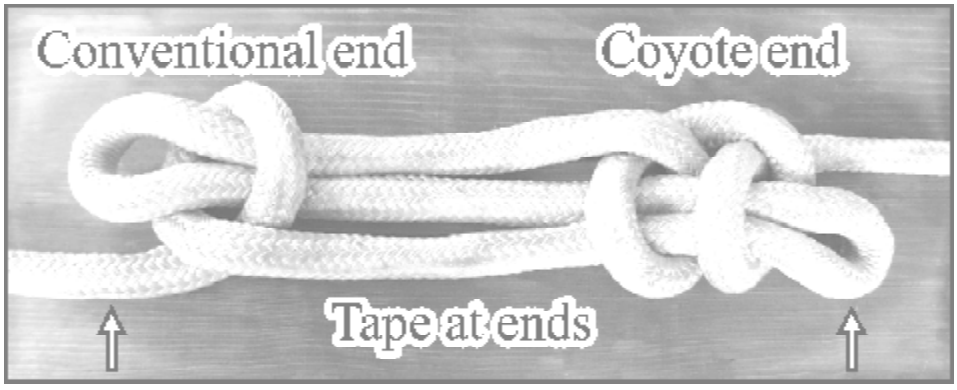


Figure 5 *Conventional and Coyote sheepshanks for shortening rope*
Photo by Harry Lewellyn

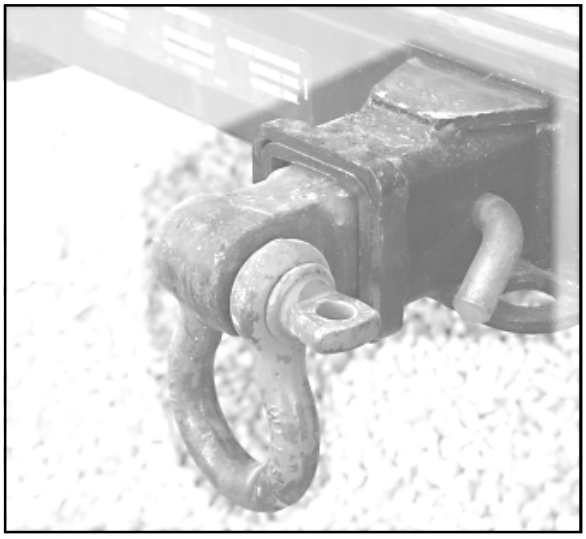


Figure 6 *A class III towing insert*
Photo by Harry Lewellyn

with this, as they both pointed out, is you've added a "cannonball" to the circuit.

Frank adds that a sheepshank is a nautical way to shorten a rope. Note I've shown the conventional knot (left end) and the Coyote version (right end) in Figure 5. My past experience with a trucker's knot (a half sheepshank of a sort) has shown the double loop (half hitch) approach withstands more stress. And with a little tape at the ends (not shown), you'll ensure either approach stays tied with and without stress.

Blaine Johnson (Dana Point, CA) suspects the class III trailer receiver pin through yanker loop may bend the pin (last issue, Figure 7). I've broken pinned yellow yankers and the pin remained straight, but have never tested round towlines. They would definitely centralize the force on the pin and could bend it. His comment brought to mind another towing and tugging class III insert. See Figure 6.

TOWING AND TUGGING DEFINED

My crawl, then walk and finally run approach definitely applies to tugging. Don't be a jerk and go for the gold on the first tug. The balance of this article assumes you have the two vehicles properly attached to each other, both vehicles' paths are clear and the stuck vehicle is safe to move. Above all, make sure the brakes and steering work on both vehicles, and both drivers have calmed down from whatever caused the problem.

Towing is simply the process of taking the slack out of the yanker, applying power and hoping your *compadre* follows closely behind. With a disabled 4WD, this would almost certainly be the case. But, if the other turkey is stuck, he may be more stubborn.

CRAWL

Still within my definition of towing (pulling with no slack in the towline) is to apply horsepower until the tires spin. Depending on the traction, you may produce considerable force, but don't depend on it. Don't be surprised if the tires spin earlier and easier than you ever imagined! With proper attachment and the equipment in top condition, "crawling" danger is minimal. We've only begun to crawl.

WALK

When you put slack in the yanker and try to snatch 'em out, you've entered the realm of tugging. Tugging begins with the process of introducing slack in the towline and driving off like a trip to the market, neglecting your partner is attached. Even with proper attachment and shiny new equipment, danger now enters the scene. You've just begun to walk.

CAUTIOUSLY! RUN!

Once you introduce 10 or more feet of slack (arbitrary Coyote number) in the line and drive off like your worst nightmare is on your tail, you've entered the realm of running. This is very dangerous regardless of equipment, conditions or experience!

A running tug, yank, snatch, jerk or whatever you choose to call it is dangerous! Tugging is unforgiving! It demands attention to safety and detail! It produces unimaginable force on every element in the circuit! One neglected element blows the fuse! It makes about as much sense to ignore any tug detail as it does to moor the Queen Mary on a shoestring!

PRELIMINARIES

As covered in TOWING BASICS: Inspect your equipment, attach only and directly to the frame, slide yank protectors into place, mouse the hooks and attach-chains, don't use yokes and take these additional precautions. Don't take shortcuts, but first, two simple basics!

TWO BASICS

Here are two simple basics that will most likely be neglected until you really need them. Try very hard to get unstuck going straight and downhill. Turning offers rolling (more stuck) resistance. Next time you're struggling along in the soft stuff, throw in a little turn. Don't be surprised if you slow down or get stuck. Straight is easier than curved, but don't drive off a cliff trying to stay straight!

Being the creatures we are, if we get stuck headed uphill, we'll most assuredly try to get unstuck in the same direction – uphill! Put Mother Nature to work for you, not against you. Real numbers: It is about 40% easier to get unstuck going down a measly 10º grade than it is to try up the same slope! I've seen situations where it's hard to tell which way is up on a 10º grade, but remember, Mr. Trapped could come coasting down into Mr. Jerk!

PARACHUTE THE TOW/TUG LINE

Install what I call a parachute. This is a blanket, sleeping bag or other large "cloth" that will act as an airbrake if the yanker breaks. I've seen people use jackets, sweaters and floor mats, but I question these little things. You drape the 'chute at the middle of the extended yanker (Figure 7).

I have no data to validate this tradition, but for now, I see no reason to change it. The thought is that if the yanker breaks, the blanket and yanker will lock together and drag the lethal monster to a speedy, harmless halt. Some of the times when I've broken yankers, they have jumped out from under the blanket, or broke beyond it, and still sped along their merry way. But until I perform definitive tests, I practice and recommend you use a parachute.

RAISE THE HOOD

Another recommended safety practice is to raise the hood on the vehicle that has the line attached to the front. This is most likely the 4X being towed, but who's to say the tugger isn't pulling backwards. And let there be no doubt, once force is applied, danger is present at both ends. The raised hood acts like a shield to keep a breaking line out of that driver's face. Use a parachute and raise your hood, but avoid the foolish alternative that follows.

FOOLISHNESS

I've heard you can fill one-gallon plastic containers with water, thread the handles along the yanker and presume this will slow down the splintered strap. I haven't tested it, but I don't believe it! If you're truly talking about forces in excess of 20,000 pounds, I see plastic water bottles as either lethal cannonballs or stationary, handle-less containers at

best. I believe it would be the latter. If a handle will support 20,000 force-pounds, shouldn't it be able to support 20,000 pounds of weight? Can you picture lifting two or three 4Xs from one plastic handle? I can't! Forget the plastic bottle farce!

CHAIN HOOK CAUTION

Your chain may be similar to the Coyote Chain I sell (see a newsletter). It uses transportation-quality chain and hooks, but it is not intended for an all-out yank. I suspect the hooks won't take it! The stuck Suburban story that follows bears witness to the forces involved. Next time you pass by a Suburban, inspect the size of the front tow hooks. By the time the stuck Chevy was moving on its own, the hooks were considerably straighter!

Figure 7 *Parachute employed on tow-/tugline Photo by H. Lewellyn*

ASSIGN A DIRECTOR

You primarily need a traffic cop, a director, *un jefe*, in addition to two rational, competent drivers. This is someone who will clear the onlookers, check the connections and ensure both tuggee and tugger are alert and ready for action. He gives the go-ahead, narrates the continuing process and is prepared to immediately shut down the whole shebang if something goes awry. He should be safely off to the side, visible and within earshot of both drivers. Both drivers should have their director's-side window down to ensure verbal communication.

DEFINE THE DANGER ZONE

Define the danger zone for all to avoid. This applies to participants, spectators, pets, other vehicles and anything of value. My method is an overkill but, understand clearly, yanker break-forces are potentially lethal. I won't argue whether the yanker could do damage in every square inch of the danger zone, I'll only say it's definitely safer outside vs. inside this area.

Here's how to define the danger area. Mentally disconnect the yanker from one end, hold it taut and walk around the tethered end/4X. Do the same for the opposite end. This will draw out something like a figure eight. This is the danger zone. Only drivers and, when absolutely necessary, the director should be within this zone. See Figure 1 on page 10. Dark is most dangerous and if I could have made it red, I would have!

AVOID THE TOWLINE

Another general rule is to avoid the towline even during setup. That means don't walk on it, over it and definitely don't straddle it. The assumption is that it could go taut at any time. The testosterone gender is naturally sensitive to and *acutely* aware of the dangers of straddling anything that could snap up between your legs!

HOW TO TUG

So a push by hand didn't work and a tow just smoked the tires. The yanker is safely attached and parachuted, the onlookers are outside the danger zone and the director is in place. One at a time, he calls to the front, then rear drivers, "Are you ready?" When both acknowledge, "Yes," the process begins.

First, give traction another try. Take out all of the slack and try a gentle pull. It's fair to give it a couple of goes, but you don't need to bury yourself trying. If crawl doesn't work, try walk.

Put a couple of feet of slack in the yanker and drive off like no one was attached. If slight progress is gained, do it again. It's completely OK to recover Mr. Stuck a foot or two at a time. It doesn't always have to be a one-shot deal. With no success, cautiously, **very cautiously**, try run.

Run gets progressively more danger ous. In essence, your 4X and movement add momentum to a traction-only tow. More slack and speed mean more momentum. The tug energy builds with the square of the speed. This means **20 MPH** is **sixteen times** more powerful than **5 MPH!** High-speed yanks introduce severe death and destruction potential. The yanker is like the energy stored in a giant rubber band. You can think of it roughly like smashing directly into Mr. Stuck at whatever speed you reach. Your airbags go off at a 12 MPH impact! Thank you, Ken Obenski, for the concept and data.

CHANGE SOMETHING

If two or three serious, all-out yanks don't work, I recommend you change something. Experience speaks.

A Suburban, San Felipe Sand Blast tour participant is buried to the frame in Baja mud. His massive weight had stuck him good! A full-size pickup's full-speed tug didn't work (plan A). We put two 30-foot straps in series only to break one strap (plan B). The nylon strap (only) went through the grille and seriously into the air conditioning/radiator. We paralleled two trucks and proceed to yank (plan C). Still no success! We switched to plan D. We jacked it up and put stuff under the tires. Three dirty hours later, the damaged Suburban was out.

The essence of the message is that yankers are great recovery tools, but not always the final solution. Don't kill yourself and others trying to perform the impossible!

FOURWHEELING ACADEMY

Loose Ends

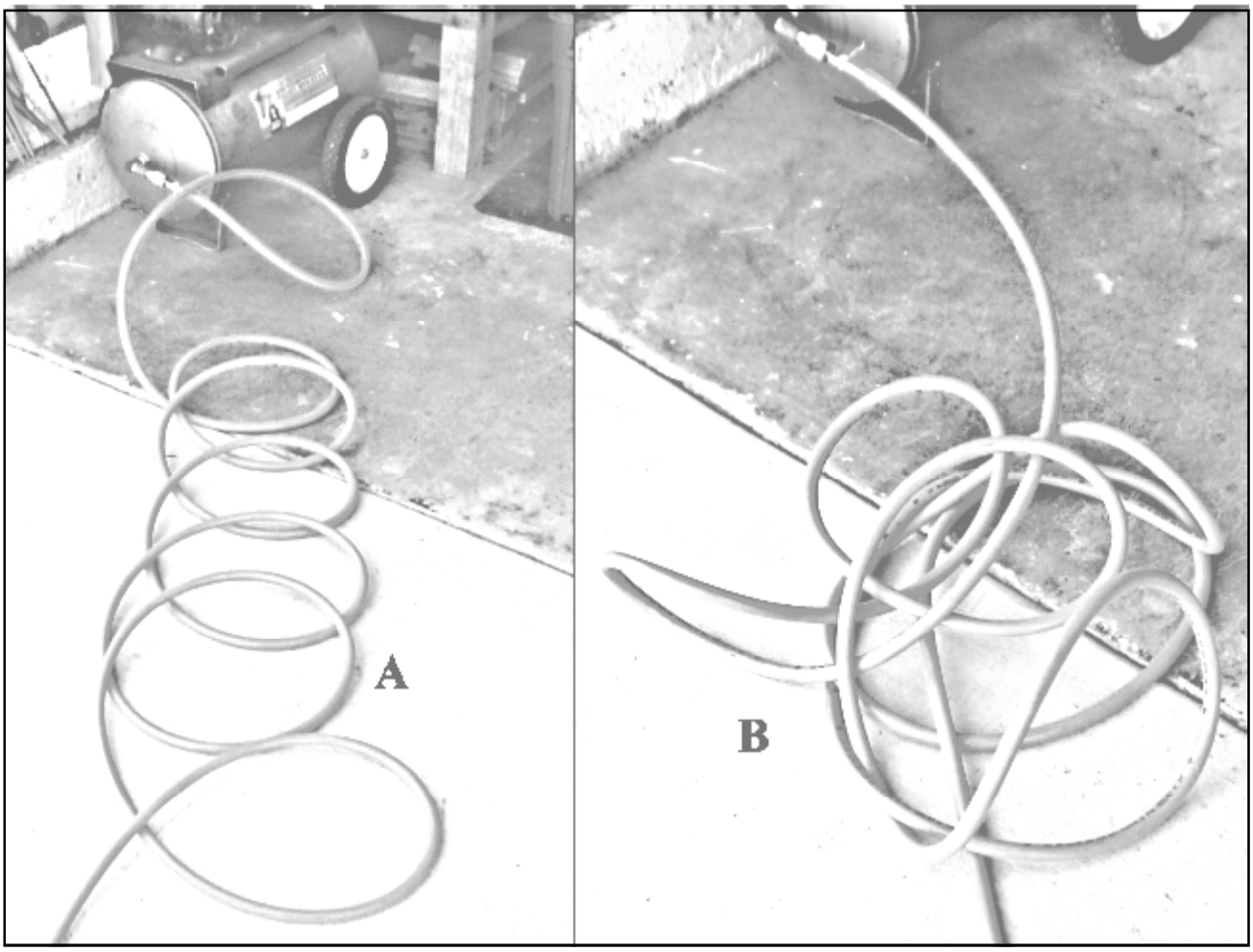


Figure 1 *Most coiled hoses and ropes end up in a mess like B above when uncoiled.* *Photo by Harry Lewellyn*

By Harry Lewellyn

This article ties up all the loose ends of the last three ***FOURWHEELING ACADEMYs***: *Yankers Away*, *Towing Basics* and *Tugging Basics*. First, I'll correct a mistake I made, then present a little known rope-coiling technique that will end your kinky uncoiling problems as pictured above. Finally, I expose the sneaky yoke monster, as I call it.

GRAB HOOK CORRECTION

(reprint corrected) Referencing Towing Basics (Nov.-Dec. '99), figures 9 and 10, I'm wrong. Emil Bjornsson of Master-Pull had called this to my attention in a telephone conversation and Marc Cooper drove home my error with several lengthy, well-documented e-mails. Figure 9 is the correct way to use a grab hook and not Figure 10 as I wrote. As I've said so many times before, I do my best, but when you know otherwise, tell me! My objective is to provide the best information possible, even if it means admitting to the terrible W (wrong) word!

Marc points out that as shown in Figure 9, the hook is only bearing half the loop load. The other half of the

loop load is borne by the "chain-side" of the loop. Further, since the hook and the chain sides of the loop are almost parallel (no yoke monster effect — explained below), there is no reduction in the total load capacity of either the chain or hook.

He goes on to point out the Figure 10 configuration will choke ("slip knot") down on the yanker and crush it. Not too cool! He makes reference to the "Crosby" product guide (www.slingchoker.com/sling2/index.htm) and bbchain.com to substantiate his information. Thanks, Marc, for the enlightenment.

CONVENTIONAL COIL

If you've ever fussed with uncoiling a garden hose, you've suffered kinking problems that are common to air hoses, ropes, cables, CB radio antenna coax and power leads, and yankers of all sorts. Pulled from a neat nest, the item will try to twist and eventually become a tangled mess (cuts off the water flow, in the case of the garden hose). My compressor air hose easily demonstrates this (see Figure 1A, ready to knot up, and Figure 1B, knotted). With flat, yellow yankers, it's even worse. I discovered what follows while watching a professional audio technician on the "Adventure Crazy" (see the Travel Channel) shoot in Costa Rica.

UNCONVENTIONAL COIL

He was coiling his cables in a most unusual way. When asked why, he said, "Watch." He pulled the cable completely from its coil without so much as a single snag. It lay absolutely flat and free before me. "Hey, I gotta learn that," I exclaimed! He went on to explain that the last thing a movie unit wants is to waste precious production time watching him undo cable catastrophes.

OTHERS' EXPERIENCE

I shared my discovery with a knotty nautical friend. He insisted centuries of seamen have always coiled a conventionally clockwise-twisted rope in the conventional clockwise direction and there couldn't be a better way. I'd been taught the same thing when driving a truck decades ago. However, after seeing my unconventional coiling method demonstration, he acknowledged the results were flawless.

In another conversation with Master-Pull's Emil Bjornsson, I related my discovery and he said, "What's new, we have to do the same with steel fishing net cables or we'd kink and kill 'em the first time off the deck." He called it an over and under coil. With next to no thought, I knew he was right on! Picture a one-inch steel cable having garden hose problems! Remember, Emil had been an Icelandic fisherman for years, so his experience is real-world based.

CONVENTIONAL PROCESS

Figure 2 is a series showing the conventional coiling process. I used a large twisted rope with an added black tracer for photography. Follow Jenna's right hand and note the flip-wrist "twist" action needed to coil the rope so it will

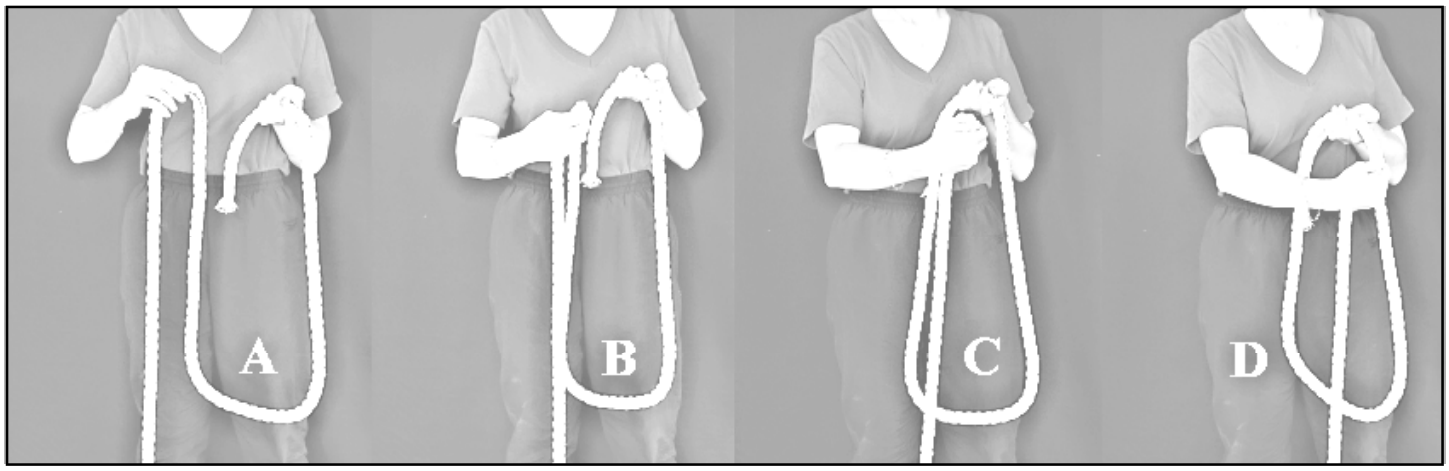


Figure 2 *Jenna begins to lay in the first loop in A. Note the wrist action in B, C and D. She has completed one conventional clockwise loop in D.* *Photo by Harry Lewellyn*

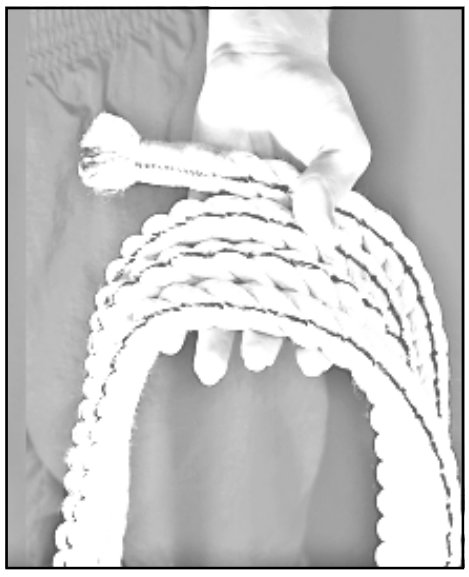


Figure 3 *This shows three conventional, CW loops.* *Photo by Harry Lewellyn*

lie flat in the holding hand. Figure 3 shows a flat-lying rope in the holding hand with no crossovers.

New method or old, I also slide my forefinger and thumb to aid the rope-twist action. With the conventional coiling process, the twisting action is always in the same (clockwise) direction. This is where the uncoiling problem lies. is no problem when the loose end is free to twirl.

Try this to see what happens if both ends are fixed. Uncoil and lay straight and flat (no kinks) your garden hose while still attached to the faucet. Now go to the water delivery end and start to neatly coil the hose in your holding hand while walking toward the faucet.

Lay the first coil in your holding hand clockwise (CW), as usual (Figure 4A). The next coil is laid in with a counterclockwise (CCW) twist action. In Figure 4C, note Jenna must acutely bend her right wrist and reach in under the first CW coil before the holding hand takes the CCW coil (Figure 4D). An X in Figures 4C and D locates the

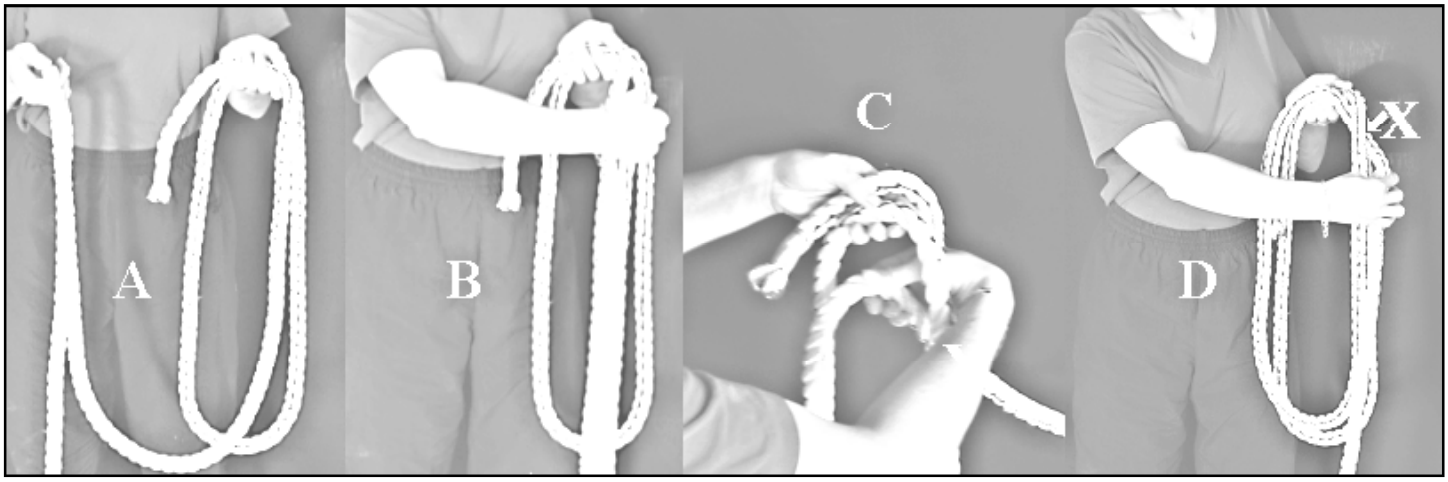


Figure 4 *Jenna has laid in the first CW loop in A. In B, she begins the first CCW (under) loop. Note in C she must cross under the first CW loop. D shows the under loop completed and X indicates the cross under in both C and D. Photo by Harry Lewellyn*

COIL TEST

Coiled as above, you have twisted the entire rope in one direction, which

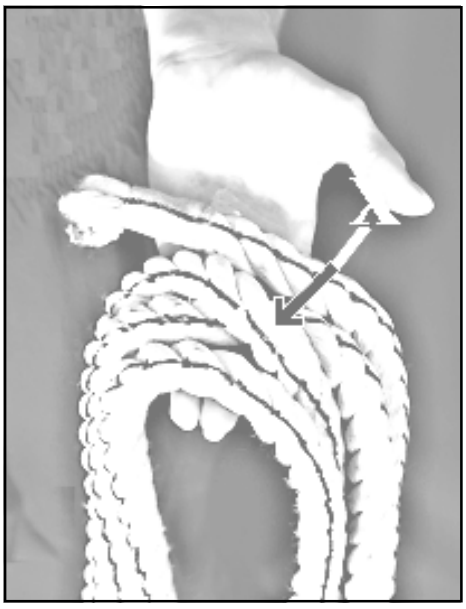


Figure 5 *This shows three loops with X the under loop. Photo by Harry Lewellyn*

You will eventually reach a point where you can no longer coil the chaotic, severely twisted and kinked mess. After you've mastered the unconventional method, try it again. You'll reach the faucet with no problem!

As already mentioned, Figure 1A shows my air hose partially uncoiled with the undesirable, unavoidable, accumulated "twist," just waiting to writhe like an injured snake into an awkward problem. This coil (Figure 1A — any hose, rope, cable, yanker, etc.) will eventually end up in a kinky, knotted mess as shown in Figure 1B if left unattended.

UNCONVENTIONAL PROCESS

Figure 4 shows an alternative coiling method. Understand, in essence, what you are doing is alternating your "twist" action from clockwise to counterclockwise, then clockwise again and again. This action nets out to zero twist in the rope. It's not particularly easy to understand or do, so here's a blow-by-blow description.

crossunder. You can clearly see the remaining rope coming out from underneath the last coil in Figure 5. This is probably the reason Emil calls it the over and under method.

The third coil is again laid in CW (over), then the fourth CCW (under) and so on to the end of the rope. Your wrist/finger action alternates from CW to CCW twist. Note the unwieldy look of the crossover after just three coils in Figure 5. It takes an extra flip to get each CCW coil to lay in underneath. I recommend you learn this with string first. Having coiled as many ropes and hoses as I have over the years, I still find the new method very awkward. The key is to remember to alternate the twist between CW and CCW.

UNCONVENTIONAL TEST

To test this method, I securely clamped the starting end of the rope in my bench vice, dropped the coil, held firm the other end and walked to full

length. I reached the end with no untwisting required. It works great!

YOKES AND SLINGS

I introduced and warned of yokes in TOWING BASICS (Nov.-Dec. '99, page 6). I once ran across a hard-core jeeper who had a chain tightly bolted parallel to, and from one end to the other on, his bumper. I asked about its use. He was a chain and cable guy and thought he gained getting-unstuck advantage by being able to hook onto the chain at any left to right point. I tried to explain to the Chainman the yoke force he had created to no avail. What follows puts numbers on this destructive monster. The science and information is not new to those who use slings in lifting and rigging.

Figure 6 shows four typical yoke arrangements and the associated forces. I chose things you're likely to use for yokes like a yanker (A), tree saver (B) or Coyote chain (C). I assumed you have one hook at each end of the front frame rails. That measures 28 inches apart on my Explorer. I further assumed the vehicle to be a 4,000-pound load, as would easily be the case with bad mud. As the attach-point angle gets greater and greater, or the legs get shorter and shorter, note what happens to the strain on each leg. I particularly call your attention to the strain on the Chainman's setup (D). Understand the force monster can sneak up on you, so in industrial applications, OSHA and other safety agencies require slings be significantly derated. Further, for ease of presentation, the drawings are not exactly to scale.

YOKE RECOMMENDATION

Keep the legs long and the attach angle tight. Assuming you have an undamaged standard 30-foot yanker, and the attach points are at about frame width, you're OK. As you widen the attach points or shorten the legs, the forces increase as you can see in Figure 6.

Where does all of this extra force go? It goes into pulling the two frame rail attach points together toward the center of the 4X. Keep it safe by only using yokes for towing and <u>never</u> in serious, all-out tugs.

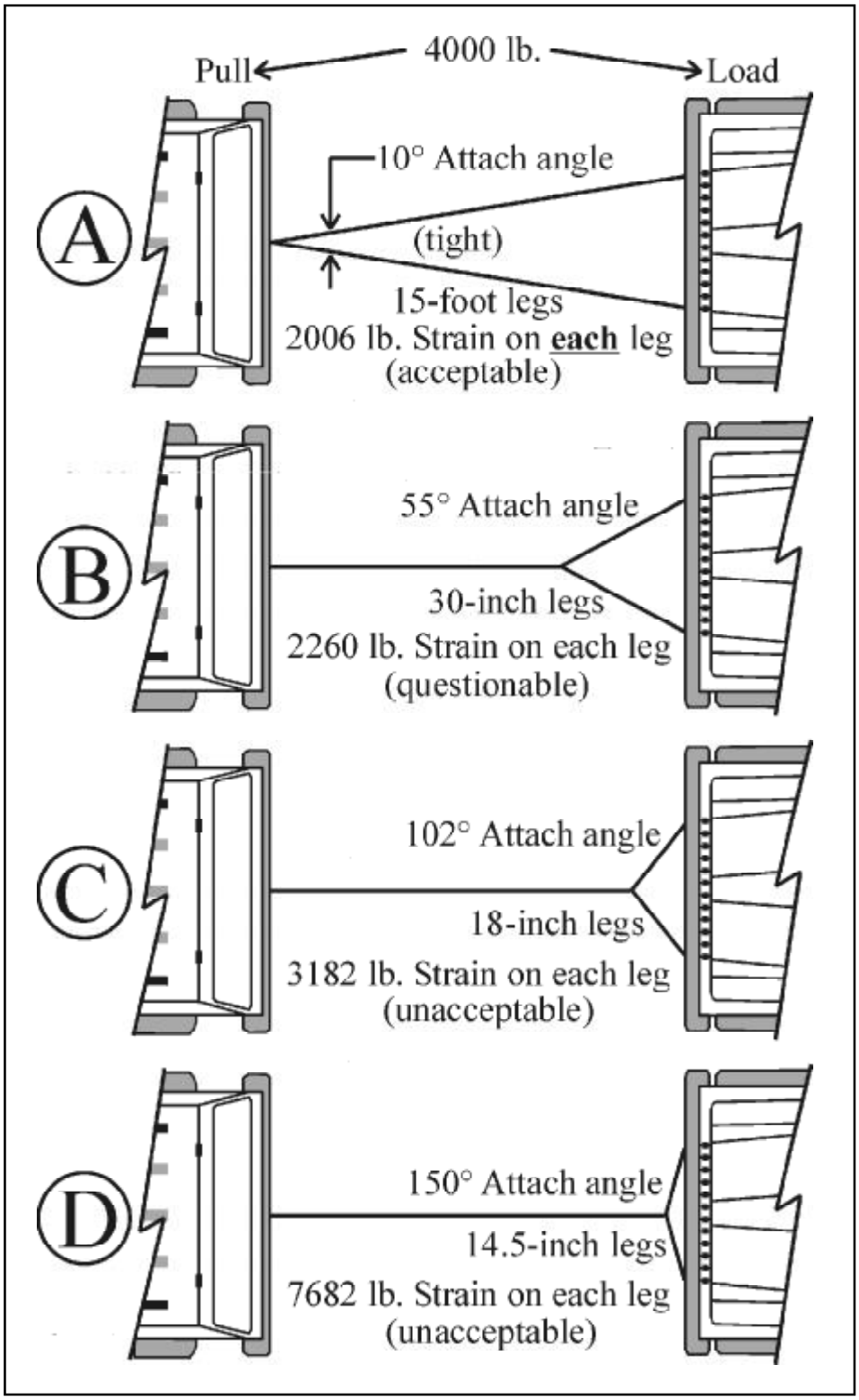


Figure 6 *The yoke monster becomes inconceivably large as the attach legs get short and the angle becomes broad!* *Photo by Harry Lewellyn*

FOURWHEELING ACADEMY

CENTER OF GRAVITY

By Harry Lewellyn

CAUTION

Read this article with safety and caution in mind. You are about to embark on an engineer's journey through center of gravity! Understand clearly the engineering world and the real world struggle to relate ... in words!

This is the first *FOURWHEELING ACADEMY* about keeping the rubber side down - rollovers. At some time or other, we have all been concerned with rolling . It's natural and it's to be expected. Your concern with level is your safety valve to survival. Learning your approximate rollover point is most crucial.

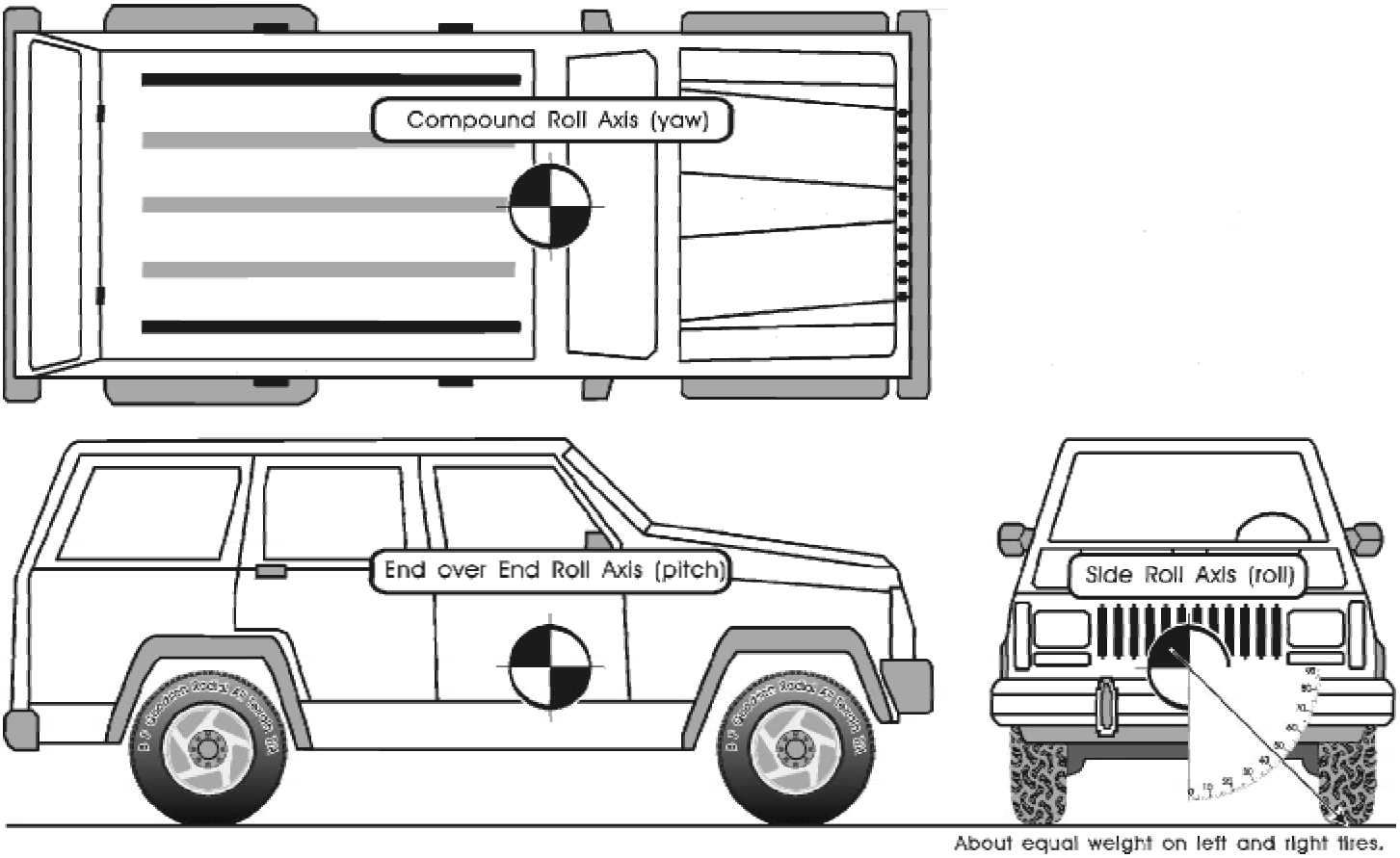
APF

In my how-to-drive classes, I refer to your A P F: your A-(something nearest your seat cushion) Pucker Factor, that under normal driving conditions, goes off long before you are actually in danger of rolling. However, there are a numb-butted few who have no fear, or maybe, no sense of level. For them, the only way to learn, if ever, is the hard way.

With the experiment described below, you will learn about center of gravity and how to determine approximately where your static rollover danger point is. With enough interest, I will conduct a rollover seminar where we actually use your vehicle, as we did with mine below. Write and let me know if you would be willing to pay ten or twenty bucks to "roll" your 4X.

EVERYTHING HAS ONE

Dogs, sticks, stars, flowers, people and cars all have one. If it has mass (when gravity acts on it we call it weight), and whether it is living or inanimate, it is the basis of balance and stability. Center of gravity is a magical point that exists for all things. It typically can't be reached or touched, but it is the basis for predicting aircraft flight dynamics, how kangaroos jump or how far a 4X can lean. And for



About equal weight on left and right tires.

the critical technocrats out there, please cut me some slack regarding the precise interpretation of terms and concepts. But for all, be aware this article deals with static (non-moving), almost laboratory-like conditions.

DYNAMICS DEFINED

The real world deals with dynamic (moving) conditions. Don't underestimate the effects of movement (dynamics). My intent is to give you a tangible basis for predicting when you are approaching rollover trouble. A future article will deal with what to do if you do roll.

CENTER OF GRAVITY - DEFINED

Center of gravity defined: Picture barbecuing a chicken on a rotisserie. You'd like to run the skewer from head to rear and have the bird turn in perfect balance. Now picture two different approaches — a skewer that runs sideways from wing to wing, or another that runs up and down from the middle of the back and out between the feet. Each of these three skewers could lead to a clucker in perfect balance — not necessarily a practical approach, but nevertheless, a smoothly turning meal.

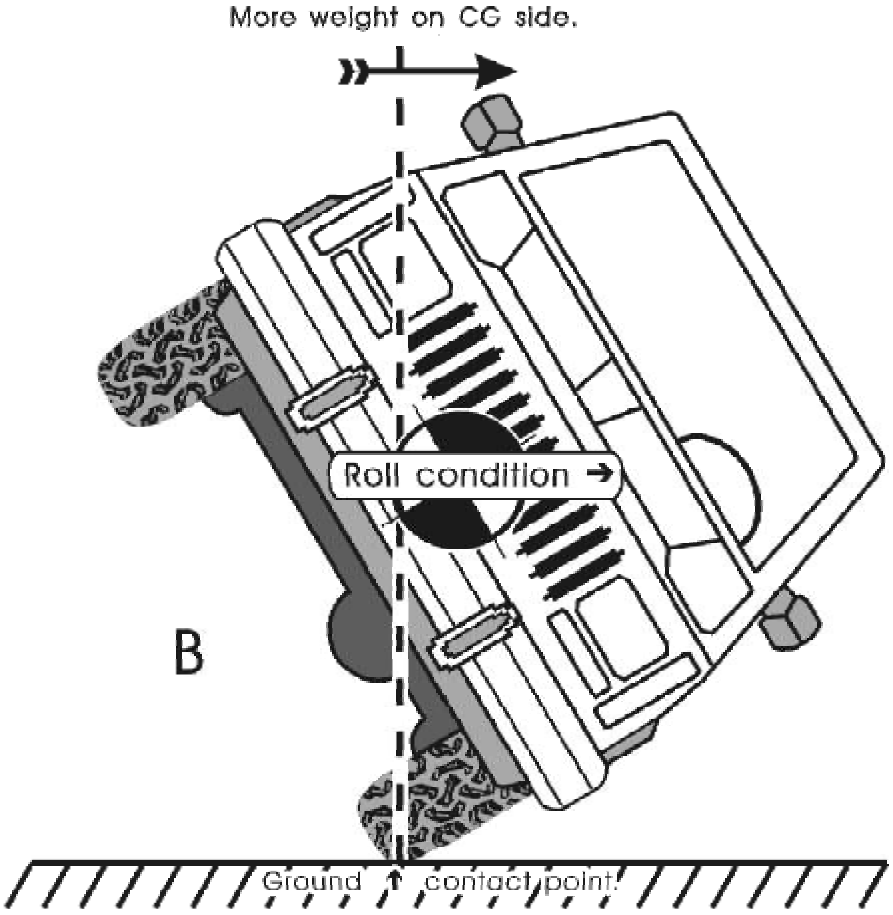
THREE AXES

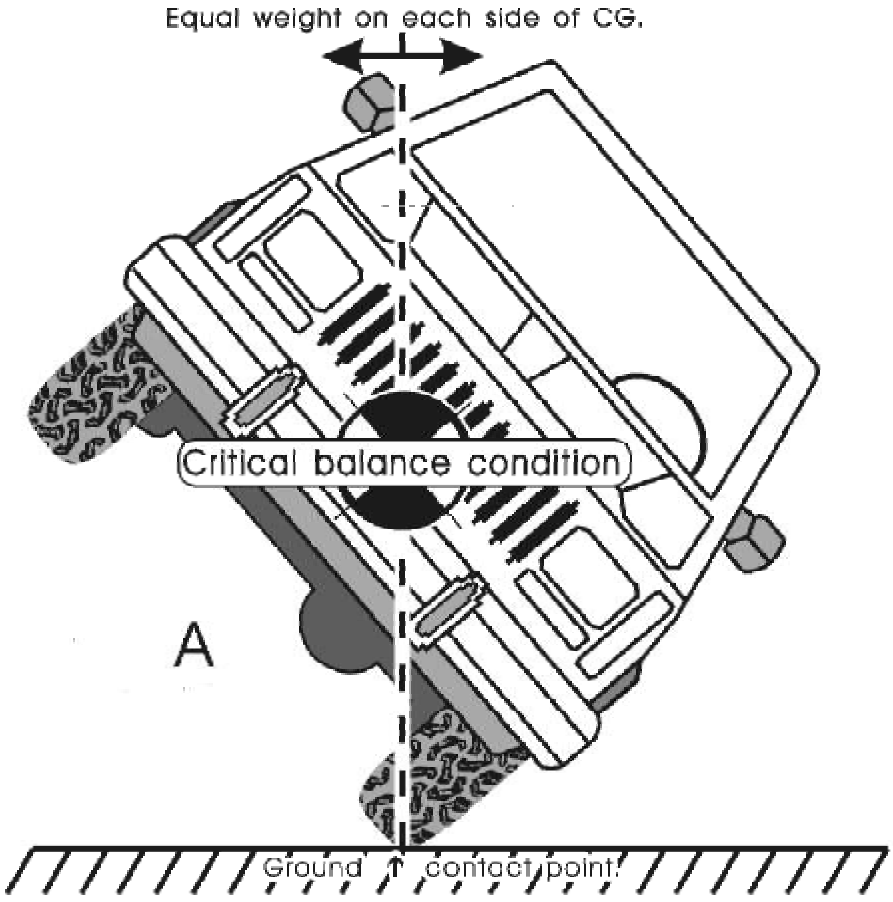
To the engineer, each skewer represents an axis of our three dimensional world. I hope it's easy to see that all three axes would intersect, cross each other, at a common point. This is because each view in the first figure has an axis in common with the other two. The intersection is the center of gravity (CG).

PERFECT BALANCE

Take this a little further and connect a magical string to the CG. Now, given that the legs and wings don't flop around like they really do, you could move the chicken to any position - head level, feet up, tail at an angle and so on — and it would stay perfectly balanced. Suspended from the CG, anything and everything is stable in every and all positions. 4Xs have a center of gravity.

The figure on page 18 is a 4X in three straight-on views (an orthographic projection). The CG axis symbol, /, in each view is like the end view of an arrow. This symbol, ¸ , represents the end view of each CG axis. We are most concerned with the head-on, vehicle, front view. Engineers please disregard traditional view designation. This view (axis) has to do with side rollover. The axis through the door has to do with steep-hill rollover — rear-end over front, or vice versa. We can disregard the





top view axis since it has to do with a compound roll where the 4X would be on its side and then roll rear-end over front. You can imagine that the actual CG (point), the three-axis intersection, is near your console.

APPROXIMATING CG

Conservatively use this generalization for most sport-utility vehicles. To help find these axes in your 4X, visualize that your CG is where your right fist would hang when seated in the driver's seat. You probably cannot get your fist that low, but that is about where the CG is located. Working backwards from your fist, mentally project the three axes to the outside of your 4X. The axis that goes front-to-back is of most interest. You might solicit the help of a friend, outside the car, to determine a reference point at the grille. Lock this in your mind for future, field reference. We'll now learn how to use this point.

USING THE CG

In the front view, with the 4X on level ground, the weight on the left tires is about equal to the weight on the right tires. As you lift the passenger side (right side) tires to higher (unlevel) ground, the weight on the driver's side (left side) tires increases. Accordingly, the weight on the right tires now decreases. This is known as weight transfer. At some point, all of the weight is borne by the left tires and the right tires are just ready to come off the ground. This is the static, side-roll, balance point. For this explanation, the 4X is level, front to back — i.e., the chicken's head and tail are level, it's just balancing on one leg.

BALANCE

The second figure (A) shows the 4X at the critical balance condition. Engineers call this equilibrium. Take note of the CG. It is directly and exactly vertically over the tire contact point. A vertical knife could cut the 4X in half, through the CG, and one piece would fall left and the other right. Each piece would be of exactly equal weight.

ROLL

Picture the 4X going farther over (B). The CG is now beyond the tire contact point and therefore more weight is on one side than the other — the 4X would roll in the CG symbol direction.

To help understand this, picture another exactly vertical cut, only this time through the tire contact point only. It should be easy to see there is more weight on the CG-side than the other.

You don't have to roll your 4X to discover your approximate balance point and angle. Using your right fist, front projection point, hang a plumb bob through the CG axis at the grille, then swing it over to the center of the tire at the ground contace point (see the first figure). Measure this angle and as I'll show below, I learned you have a pretty good approximation of your static balance or equilibrium point.

The above is what I have taught for years in class, but I truly did not know the reality of my "guestimated" CG. With the help of Mark Hinkley and Don Gilgan of the Off Road General Store in Laguna Hills, and others, we put the plumb bob to the metal.

CAUTION

The CAUTION: First and foremost: all of the details are not presented in the following brief description of the experiment, so don't try this yourself. Secondly, if you must try it, muster up all the safety, caution and common sense available before proceeding. Again, this experiment is best left to those with some engineering sense and experience with vector resolution of forces. Also understand the results are less than perfect. Suspension travel, tire air pressure, load and many, many other factors were only briefly considered.

THE EXPERIMENT

The experiment: Take a 4X and connect yank straps at one point near the top, (front-back) center of the vehicle like the B post. Now extend the straps in opposite directions, perpendicular to the side of the 4X. Connect two 4Xs with winches, to the straps, at right angles to the side of the first 4X.

You know what to do now — take in one winch and let out the other. At some point it will be obvious the 4X is falling in the pulled direction. Back off a bit until you determine the balance point, and then measure it. Actually, the hard core are probably rolling on the floor, because this is the way they change tires.

With much safety and apprehension, the photo shows the results. What surprised me was the fact that the 4X leaned a lot farther than expected and my right fist approximation was relatively conservative. What I also learned was the seat-of-the-pants feeling for my rollover point. My APF went berserk! I was actually sliding off the seat bottom before I would roll. I'm not going to give you the actual number, but it was in excess of 45°.

TOUGH TIRES

I was also pleased and surprised to learn the tires did not deflect or colapse off the wheels. The BFG Baja TAs appeared as though they were on level ground — virtually no side displacement.

We repeated the experiment with Don Gilgan's Wrangler and the recently rolled (post test), Chuck Thompson 4Runner. See his *Rollover Revelations* on page 28. They too showed greater than 45° tilt angles and the slide-off-the-seat feeling.

We also tested my Explorer with driver, driver and two passengers, and a load on top in a couple of positions. I was amazed how little these load variables affected the CG.

CONSERVATIVE CONCLUSION

These tests indicate when going very slowly, so the dynamics (movement) of the situation do not enter into the equation, and under ideal conditions, it is most likely your 4X would slip sideways on a sloped dirt or poor traction road before it would roll.

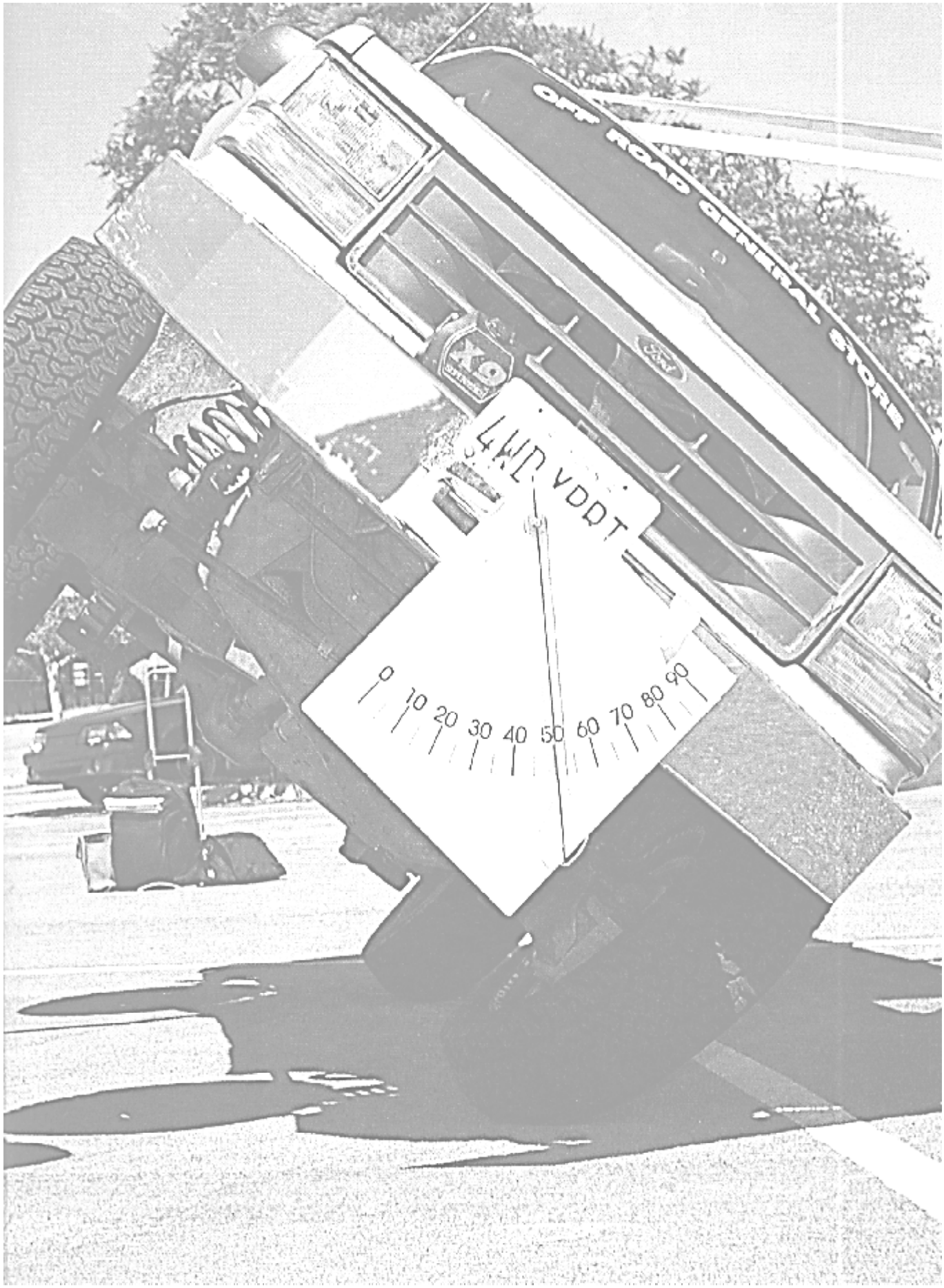
NEVER UNDERESTIMATE THE EFFECTS OF MOVEMENT!

But it is obvious that 4Xs do roll, so never underestimate dynamic effects or what I call compound angles. Calculations, not presented here, indicate a combination of going down-hill and side-tilt are most dangerous. Chuck rolled in a compound, down-hill, side-tilt situation.

Further, picture you can drive in tight circles at a high rate of speed and roll any vehicle. You can also be moving on a less than critical tilt angle, hit a bump, and roll the vehicle. Repeating - NEVER UNDERESTIMATE THE DYNAMIC EFFECTS OF MOVEMENT!

The preceding is a disclaimer of a sort. What I would like are your personal experiences and insights about all the above to further improve the accuracy of this information. I want to present the most accurate and useful information possible. If I have erred, please write and tell me so I may pass along your knowledge. And in the same breath, I must ask for an engineering approach to new information. I shy away from chest pounding, suspender stretching, unsubstantiated claims.

The next article will have to do with after you are off the rubber and on the metal. To help with the spectacular side of rolling, I welcome your photos and experience on this too.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FOURWHEELING ACADEMY

ROLLING: Passenger Recovery

By Harry Lewellyn

QUESTIONABLE EXPERIMENT

I didn't get enough takers on the roll your 4X offer last month to justify having a seminar. And I didn't get a barrage of inputs and corrections about center of gravity either. I don't know whether that's good or bad, but Jimmy Nyland of 4Wheeler magazine brings up the most important observation. The winch-over experiment does not have the high-side tires on the ground therefore the validity is in question. His prompting, and another pass at the experiment warrants a follow-up piece taking this into consideration. However, we both agree dynamics — movement - must be taken into account, and at best, winch-over test information should be used with a great deal of caution!

This no high-side tire touch business is worthy of the considerable discussion that follows. There may be some validity to the tire not being on the ground matter, but I reason as follows. At the exact point when the 4X is balanced (about to roll), the tires would literally be off the ground anyway.[1] Picture it like the old cigarette paper ignition-point test to determine exactly when your points are about to open. Kids ask dad what ignition points are! With the ultra thin paper (sensor) under the high-side tires, at exactly the moment just before roll, you would be able to start to gently drag the paper from under the tire. In essence, the wheels are off the ground at the balance point regardless of whether they started out touching the ground or not. This being the case, I conclude the test is reasonably valid. However, I suggest you consider what follows and I'd like to improve the experiment.

READER REQUEST

An open request to all readers. What I am looking for is a section of concrete or pavement which makes a gentle transition from flat (horizontal) to near vertical, with a flat (level) area on the high side. Picture a riverbed or irrigation channel with sides as described. Above the channel (transition area) is a road for an anchor vehicle. In essence, the upper vehicle can belay the roll vehicle. Anybody have any legal suggestions?

Short of this real world test channel, I will perform and report another approach. I will simply chain (fix) the suspension in the normal and various partially extended positions and measure the winch-over angle. I believe the weight of the suspension fixing mechanisms will not significantly change the actual center of gravity. Do any of you have other ideas or suggestions?

HIGH PRESSURE GAS SHOCK CAUTION

Looking at another aspect of this tires on the ground business, consider the type of shocks involved. This is the kind of information I suspect high pressure gas shock manufacturers probably don't want you to hear. This variety of shock significantly distorts the above balance point reasoning, which I learned the hard way a few years ago.

Picture my experiment as described last month and above. With conventional shocks, the front/rear, high-side tire/axle combos hang to a specific position when tilted. Also understand high pressure gas shocks always want to fully extend themselves, or in effect, to a certain degree, provide spring-like lift. They try to extent their associated spring elements (leaf, coil or torsion bar) beyond their normal, quiescent, rest positions. And without going into the numbers, this is particularly accentuated in a tilt situation.

So let's take a tilting truck, with conventional shocks, to within a fraction of a degree of rolling. The unit is still stable — its still on all four tires. Now, leaving it tilted, but stable, change the shocks to high pressure gas units. My guess is, with the high-side tires touching the ground, the lifting force, the extending action of the high pressure gas shocks on the high side would now push the truck past this previously stable point, beyond the balance point and over.[1] If you have high pressure gas shocks, in my opinion, you must reduce you static, winch-over roll test results.

You might say the shocks don't provide that much lifting force, but I argue near balance, it doesn't take much force to move the 4X in either direction — toward stability or roll! Throw multiple high pressure shocks into the experiment and you've really got a rollover kicker. I plan to calculate these forces, along with the follow-up experiment above and give you real numbers in a future issue. In the meantime, lets get on with rolling.

FIVE PARTS TO ROLLING

Don Carter (and I agree) divides a roll scenario into five elements: 1) pre-roll, 2) the roll, 3) passenger recovery, 4) vehicle recovery and 5) damage assessment. One, two and three will be covered this month. We'll leave four and five for another issue.

PRE-ROLL

Pre-roll starts before you leave the driveway. Secure everything! If it ain't tied down, it could be lethal in a roll! Your unsecured flashlight and fire extinguisher; the ice chest in back; the yank strap and clevis pin you just used, and even mans best friends of either variety can be a hazard when you roll.

Don also has a very graphic way of getting your attention regarding tying things down. Lay on your back face up. Now picture whatever you don't want to tie down being dropped in your face from

three or four feet above. Get the picture — tie down everything!

CHECK UNDER THE HOOD

Now peek under your hood and make sure this compartment is roll checked. The drop in your face test may be a little foolish for these parts, but do take a serious look at everything. Your battery and aftermarket additions are particularly good candidates. These, and any loose parts can either do harm or be damaged in a roll.

Battery mounts are consistently weakened and eaten away by acid. The additional connections you have made for electrical accessories may put the hot wires closer to the hood or other electrical ground areas than expected. This means dangerous sparking when dislodged or bent during a roll. The racers try to preclude sparks by putting a nonconducting shield over the entire top of the battery.

How about fuel lines, auxiliary tanks and valves, and special filters that you've added outside the engine compartment? Gasoline and your electrical system combine to present your greatest potential hazard provided you survive the roll. As you inspect the underside and the balance of the 4X, think about fire.

I like to have a fire extinguisher accessible from the driver and passenger seats, without removing the seat belt. You can't always predict where you're going to end up, or how the interior will be arranged, but one thing for sure, seat belts definitely limit your movement both during and after a roll. Make your fire extinguisher accessible when you are seatbelted in the car.

Have you noticed that a rollbar seems to be way down on the discussion list? As mentioned below, I've been involved in quite a few rollovers and in all cases, they were relatively gentle, and almost slow motion affairs. Given reasonably rational behavior and judgment, the violent, high speed stunts you see in the movies are left to the silver screen or the race track. In summary, I won't ride in a car without a conventional metal top or rollbar, but I also depend on rational behavior for another degree of safety. Leave racing and chest pounding to those with specially equipped vehicles.

IT CAN HAPPEN TO YOU

I'm not going to go into a lengthy discussion about anti-roll driving skills, but be real clear, if you drive the rough long enough, it will most likely happen to you too. I've been close to 12 rolls and most were with reasonably experienced drivers including one Camel Trophy participant. Walt Wheelock was over 80 years old when he did his!

MOST DO THE WRONG THING

Time and again I see people do the wrong thing. I believe I understand what two things go wrong. One has to do with our natural tendency to first resist virtually everything. The other thing is our misconception of what and where safety is!

On the Carrizo tour we go off the Diablo Dropoff. It's mild for the experienced and very intimidating for the beginner. Mother Nature wants to not only send us down the slope, but also slightly to the left, toward a big ditch! Beginners resist the left push with a right correction — up a steep side bank. Continued right correction will lead to a roll into the ditch. Turning in the direction of Mother Nature's gentle push leads to a successful trip down the dropoff. Like loosing control in a turn, it is usually best to turn in the direction of the slide or Mother Nature's nudge.

We are on the road, we start to go off the shoulder and we immediately want back to (apparent) safety — the road. This is particularly true for Baja paved roads. The slopes off the side of the roads are quite steep and they are the last place you want to be sideways at 50 MPH! Our desire to get back to safety puts us sideways on the side-slope and hence we roll. Same goes for dirt roads. When we see the danger off the edge, want back to safety and create the roll.

CHOOSE STUCK VS. ROLLING

In most situations the main objective is to keep the vehicle on all four tires, even if the vehicle ends up heading for hopelessly stuck. Less bodily injury and vehicle damage will occur if the rubber side stays down. Choose stuck versus rolled! With the greasy side up you have two tasks; one to right the vehicle and next, get unstuck.

PLAN AHEAD

The best driving practice is to plan ahead. When facing a potential rollover situation, or for that matter, at all times, have a contingency plan for the "what ifs." For rolls, this is most often simply turning straight downhill. Eventually these mental exercises will evolve into instinct. Instinctively knowing what to do is your best tool to handle a surprise roll.

My brother best describes what you do during the roll. Make love to the gear shift lever! Get down, cover your head and keep all body parts inside the 4X. If your roll is slow enough, get off the gas pedal and think about applying the brake.

I have actually rehearsed getting low; checking out how the center console interferes with my low profile; practicing how I will hold the shift lever and how the seat belt moves when approaching a dangerous situation.

PASSENGER RECOVERY

Passenger recovery actually starts with those outside the vehicle. Our tendency is to blindly rush up to help. Wrong! I know you've all been taught God, motherhood and the pursuit of apple pie are foremost to helping others, but the first priority is always rescuer safety. Given an unstable 4X, you could end up with two disasters.

RESCUER SAFETY MOST IMPORTANT

Rescuer safety is the first priority. The rescuer can be outside or within the vehicle, with special considerations for each.

VEHICLE STABLE?

Is the vehicle stable? Has it stopped moving? If so, approach with all senses on alert. We are a visual animal, so our tendency is to only use our eyes. Look for all potential problems: instability; fire; leaking gasoline; electrical sparking.

USE ALL OF YOUR SENSES

Also remember to use your other senses. Your nose can detect a gasoline leak long before your eyes find it. Same goes for your ears. They can hear electrical sparking and potential instability where vision fails. Use full sensual vigilance!

APPROACH FROM THE HIGH SIDE

It should also make sense to only approach from the high side. The 4X could become unstable and roll on to you.

ADVANCE WITH FIRE EXTINGUISHER IN HAND

Another not so obvious thing is to advance with fire extinguisher in hand.

CHECK THE VEHICLE

From within, turn off the ignition and all electrical accessories. Then set the

brake, put the car in park or in gear. As silly as it sounds, on two occasion, I have righted a car only to watch it roll off down hill.

ASSESS PERSONAL AND PASSENGER INJURY

Next is personal injury. Assess you and your passengers' need for medical help. Without being to gory, think of the ABCs of first-aid - air, bleeding and cardio. If the vehicle is stable, attend to critical medical problems from within.

BEWARE OF THE SEATBELT

Usually, you're a little shook up, but otherwise OK, so you want out immediately! Beware of the seatbelt hazard. You will find the buckle difficult to unlatch, so the obvious, but wrong thing to do is attack the stubborn critter with both hands. Consider your position and act accordingly. If you are up side down, you need to prevent falling on your head, and I've seen this simple mistake happen! The driver can brace his legs under or around the steering wheel. The passengers have to use more creative means to keep from falling out of the seat.

If you are on your side, have the low-side person get out first. Unbuckling the high-side occupant first can lead to down-side personal injury.

STAY ALERT

As you begin to move to get out, keep your senses on full alert. Is the vehicle remaining stable? Another natural tendency is to want to open the door. Forget it! Use the window. You'll find the doors hard to open and a potential hazard due to gravity pulling them in unexpected directions. And I suppose it goes without saying, with an up-side-down 4X, get out on the up side of the slope.

With a car on its side, you have no choice — the down-side door/window is on the ground, so the up-side is your exit path.

UNFAMILIAR UNDERSIDE

Another consideration while on your side is exposure to unfamiliar undercarriage like hot exhaust system and sharp metal. I still own a pair of sandals which bear a scar in the sole from a hot muffler.

MAKE THE FIRE EXTINGUISHER ACCESSIBLE

Before or as you exit, put the fire extinguisher outside. Either pass it to others or place it so it is accessible when you exit. Remember, you may still have another person to remove and vehicle recovery itself can cause a fire. I suppose, if you are really alert, and it's safe, you can also remove your recovery items like yank strap, chain, comealong and other items.

VEHICLE RECOVERY

Vehicle recovery and damage assessment are for another issue, along with further experiments.

[1] Experiments since this article was written have proved this assumption to be wrong. In some cases, high pressure gas shock can push a vehicle over as described. In essence, the tires stay on the ground long after the vehicle is at equilibrium and rolling.

ROLL RECOVERY TOOLS

- **Fire Extinguisher**
- **Yank Strap (rope or strap)***
- **Comealong (hand winch)**
- **Winch**
- **Hammer (big)**
- **Tree Protector**
- **Coyote Chain***
- **Gloves**
- **Shovel**
- **D Shackles**
- **Pry Bar**
- **Duct Tape**
- **Snatch Block**

**** See a current newsletter or www.eco4wd.com/products/Hardware/hardware.htm***

FOURWHEELING ACADEMY

ROLLING: Vehicle Recovery and Damage Assessment

By Harry Lewellyn

In March, we treated the first three elements of rolling: 1) pre-roll, 2) roll, and 3) passenger recovery. This month, the *FOURWHEELING ACADEMY* picks up with the last two: 4) VEHICLE RECOVERY and 5) DAMAGE ASSESSMENT.

CAUTION

As with this whole business of center of gravity and rolling, I must again add the cautions and conditions. It is impossible, or at least impractical, to address all of the circumstances, situations and solutions for all rolled vehicles. I start out with my and other's experience that most backcountry rolls are of a somewhat gentle nature. They are not of the race and silver screen variety. With these more drastic events, in a sentence, save the people and leave vehicle recovery to professionals!

VEHICLE RECOVERY

Regardless of the final position, and repeating from March, first check vehicle stability, fire, gasoline leaks and electrical sparks. I also feel I left out another possibility in the March treatment of passenger recovery. Consider stabilizing or securing the 4X before attending to the passengers. Just because it has stopped moving, doesn't mean it is stable. It could still roll or slide. Check to see that the 4X is in gear or in park, the emergency brake is set and the ignition key is off.

On one occasion, I did a gentle quarter-turtle on to a small rock and came to rest on a rear fender near the tail light. Given unwise movement by the occupants, or the rock, the Cherokee could have ended up tumbling farther down the bank. What I chose to do was tether the high-side B post (the one between the back of the front door and the front of the back door windows) to a tree with a yank strap. I do not believe in trying to stabilize a vehicle by building up the downside with rocks or what have you, particularly when it involves earth and rock movement on the downside. All downside activity is dangerous.

If the passengers are safe and the vehicle came to a stable rest on its tires, move on to DAMAGE ASSESSMENT below. If not, take time to look over the situation.

ACCESS SAFETY

By now, you probably think it's an overkill, but reassess vehicle stability and fire potential. Make sure the onlookers are away from the downside, not smoking and keep the fire extinguishers handy.

ACCESS THE SITUATION

Now, look for existing damage, the easiest way to right the vehicle and what additional damage could be caused while righting the roll. Keep your other senses on alert too: smell — gasoline or battery acid; sound — sparks or vehicle movement; vision — all the above.

ABANDONMENT DETAILS

If you must go for assistance, remove all valuables, then go for the necessary parts or recovery help. If it is obvious the righted vehicle will be incapable of moving either under its own power or under tow, or it cannot be steered due to damaged or detached steering hardware, consider righting it anyway to protect Mother Nature. Virtually all vehicle fluids are a hazard to plants, animals and man. Also, the longer it's abnormally positioned, the more likely you will have abnormal problems. Maintenance-free batteries can eventually leak acid. Oil can slowly seep into the tops of the cylinders. Brake fluid can leak from the reservoir. Gear oils can leak out the vents and so on.

PRE-RIGHTING FIXES

Provided the work can be performed in a safe, timely manner, and it's practical, considering fixing (some) things that are wrong before righting the 4X. It may be easier.

RIGHTING DAMAGE

Righting damage is usually minimal, or at least of minor concern. Things to watch for are breaking additional glass, bending good sheet metal, causing suspension damage or damaging an otherwise good tire. Consider removing items like external spare tires, gas cans, roof racks or lowering the windshield before starting the flip operation.

RIGHTING BASICS

Here's where the infinite variety comes in — righting the vehicle. Following are the basics. I find it typically more practical to use manpower versus machinery. It's easier to get her on her feet downhill versus uphill, however, you may be rolling over fresh metal or pushing into impossibly stuck. In addition, righting uphill means the work force must be on the dangerous, downhill side! Consider how stable the 4X will be after she's on her tires, too.

MANPOWER CONSIDERATIONS

Using manpower has several considerations: 1) wear gloves; 2) a displayed underside exposes unfamiliar hot and sharp things; 3) the physical size and number in your workforce; 4) how many people can be positioned on the vehicle; 5) what hand grips are available on the vehicle for the righting crew; 6) who grips where; 7) the *tough spot*, and 8) backing off when balanced.

WHO GRIPS WHERE

Who grips where means the shorter guys should be positioned at the hood and the taller guys at the roof.

TOUGH SPOT

The *tough spot* is that point when everyone needs to transfer their grip from lifting to pushing. Work out a plan where this is accomplished one person at a time. Given everyone changing positions at the same time, you may find the 4X back on the metal and someone hurt! Become military like in your discipline. Have one (reasonable) chief and the rest braves. Discuss the plan before the operation, not during it! Listen to everyone's inputs before acting. I figure I'm lucky to be right half the time. Once the 4X is balanced, don't continue to push so hard you roll it over again or farther down the

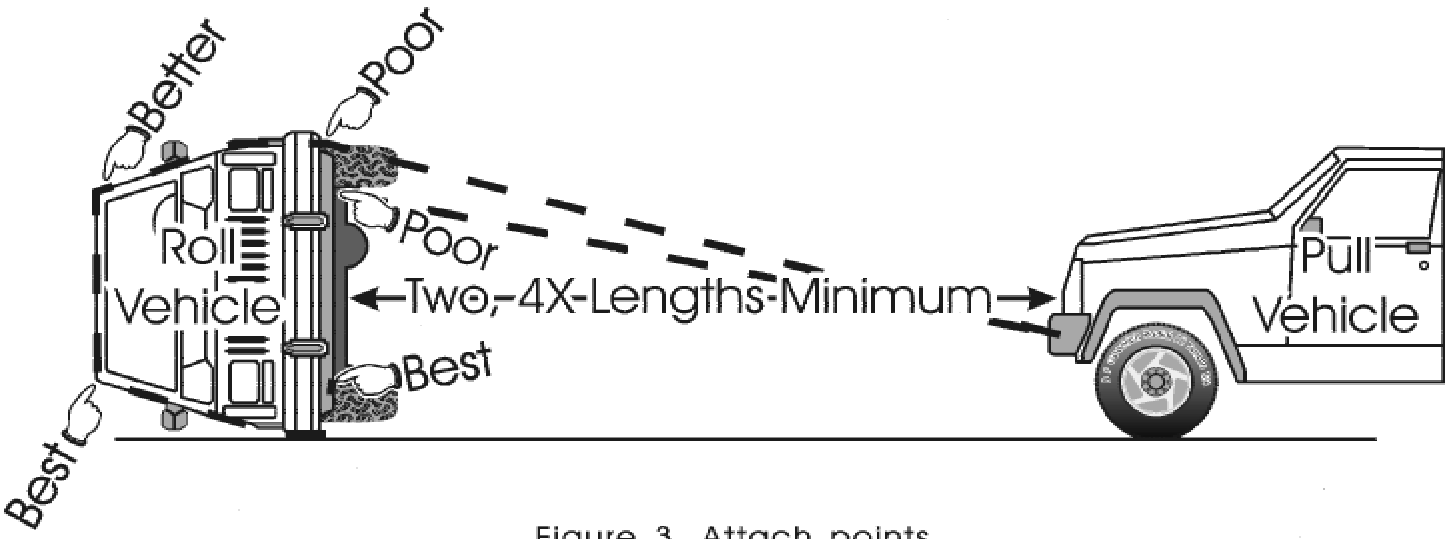


Figure 3, Attach points

hill! Finally, use your legs and not your back muscles for it will take a little more extra effort than you probably anticipate. It always feels to me as if someone else is not doing their share, and I'm sure the others feel the same way about me.

USING MACHINERY

A complete description of using machinery is beyond the scope of this article, too, but again, a few pointers will help. Machinery is another vehicle, a winch, a come-a-long (hand winch) or something that gives you a mechanical advantage over simple manpower. In the last category falls improvised rope and pulley arrangements, or fulcrums and levers (lumber and logs). Consider all of your resources!

ATTACH POINTS

The common denominator for all cable/rope/chain/yank strap oriented work is attach points and pull angles. These figures graphically tell the story. These words attempt to tell why.

Attaching to the nearest, highest point will tend to drag the roll toward you and not right it. The figure above prioritizes the attach points.

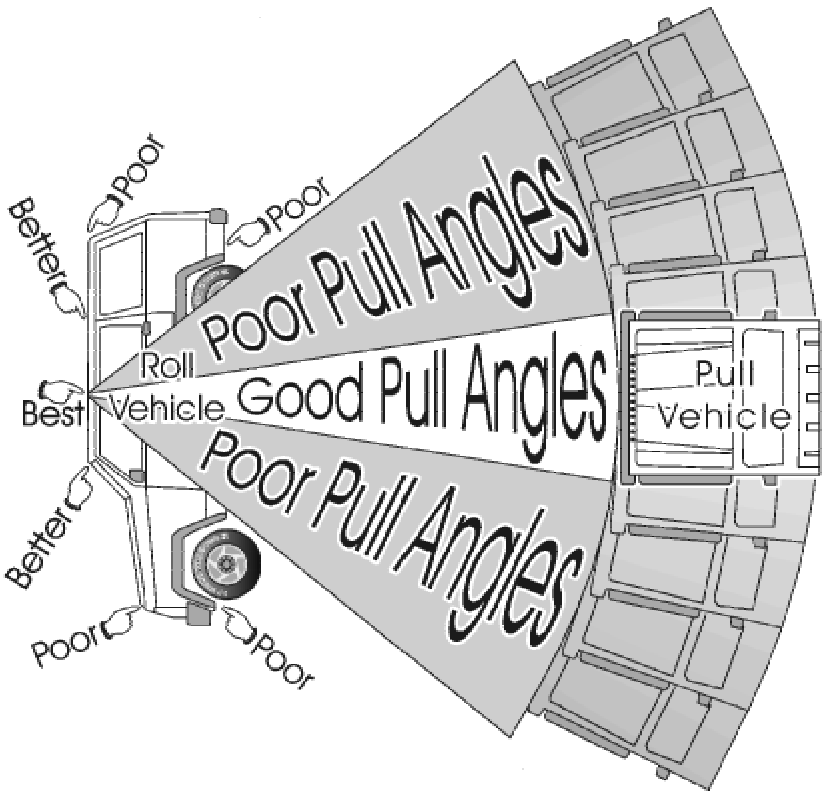
Attaching over the 4X applies much needed down force and continues to yield maximum mechanical advantage throughout the entire righting process. The hard part is to find and get to a convenient attach point for this wrap-attach technique. The frame and window posts are best. Least desirable, and very likely dangerous, are mirrors, roof racks and sheet metal mounted light bars (roll bars).

Tow strap pull-direction is another critical factor (see the figure, right). At a right angle to the roll is best, but you have to adapt to the surroundings. Consider using your winch snatch block(s) and Mother Nature's resources (trees and rocks) to achieve optimum positioning for the line attached to the rolled vehicle. Remember to use tree protector straps, if you use plant life. Also, be sure you are far enough away from the roll to allow full rollback. It should be obvious too close is impractical from both the leverage and vehicle clearance standpoint.

Another pull scenario is to relocate in a series of vehicle-pull maneuvers. This requires you safely stabilize the roll while relocating the pull.

Finally, consider yank straps stretch under tension. A loaded nylon strap is potentially lethal. Use all winch cable-related safety precautions, such as a blanket (what I call a parachute) on the pull strap, just as with getting unstuck. Also, yank straps do less paint and metal damage than do cables, chains and ropes.

Consider it fair, when safe and practical, to dig to maximize your righting advantage (see figure right). Five points on this digging thing: 1) be safe; 2) respect Mother Nature's sacred domain; 3) dig channels to the best attach points; 4) if the righted 4X could end up still unstable, dig a more level landing platform for stability (see figure to right); and 5) dig full body length, under the high-side, to lower the



fulcrum, nearer mid-4X, to ease the righting process. Items 4 and 5 apply to an uphill pull.

As with manpower, slow and easy at the last is important. Except in very few circumstances, time is an asset. I call it compounding and complicating the problem. You start out with a mechanical problem — a rolled vehicle — and in the righting rush, you end up with a medical problem — an injury. Take your time!

DAMAGE ASSESSMENT

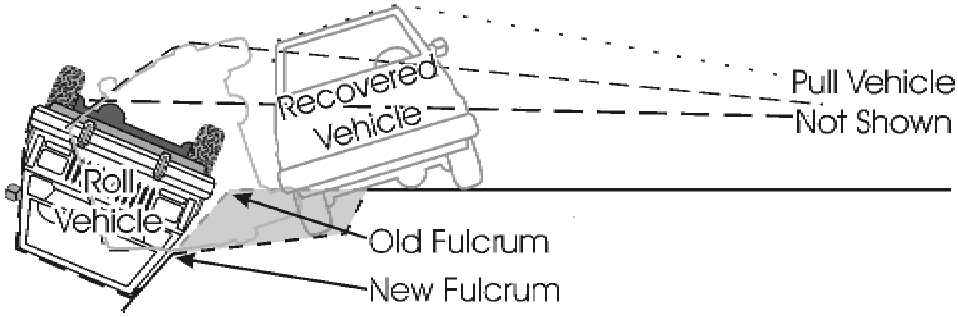
If there are an infinite number of conditions to right a roll, then there are even more damage assessment conditions (mathematicians squirm). We'll again take a general approach and make no attempt to tell you how to fix what's wrong.

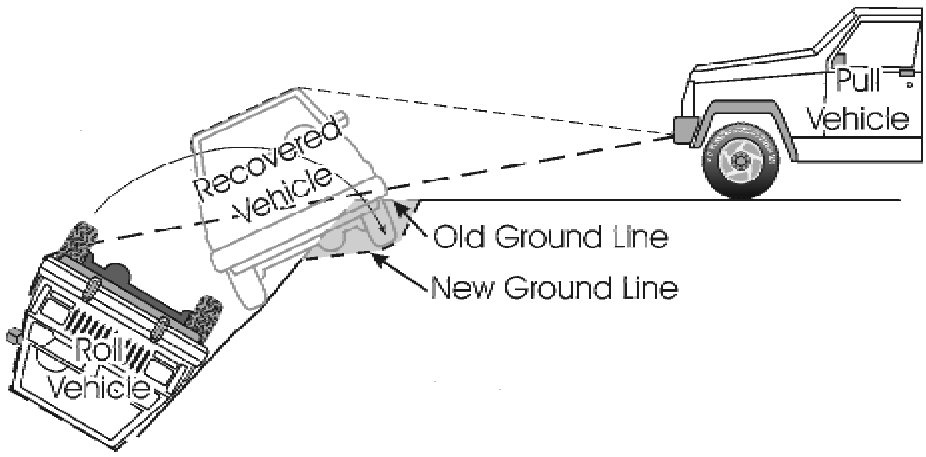
With fire extinguisher in hand, and if practical, walk completely around the righted vehicle. You are looking on the top, sides and underneath to see if the car can be moved and whether or not it can be safely driven. Look for: 1) hazards — fire, gasoline leaks and electrical sparking; 2) flat tires or bent wheels; 3) wheel alignment; 4) loose body or mechanical parts; 5) bent drive shafts, stub axles or suspension elements; 6) disconnected exhaust system components; and 7) broken glass.

Raise the hood and immediately determine if it can be latched down again. You don't want it popping up on the freeway trip home. Look and smell for gasoline. Check the battery for spilled acid and position integrity. Has it come loose? Neutralize spilled acid with baking soda and water, or simply rinse with water. Don't immediately fix electrical problems if you smell gasoline! Check all fluids. Check fan clearance.

ASSIGN A DIRECTOR

Someone other than the roll victims should be in charge considering the adrenaline could still be flowing! The person behind the wheel must be in full mental contact with reality for the next few tests! That motionless, deep space stare of the roll driver and passengers is not a good choice for behind the wheel! Also, at some point before you plant your bottom in the drivers seat, broken glass should be removed from inside the 4X. Pay particular attention to glass that could continue to break while driving either on the dirt or freeway. Consider completely removing or taping broken panels.





ENGINE CHECK

If everything seems OK, disconnect and ground the ignition coil high voltage wire, and crank the motor a little at a time. Modern electronic components and ignitions can suffer fatal damage by cranking with the coil wire simply removed and "floating" in the air. The coil must be grounded or allowed to spark the equivalent of the sparkplug gap, but not if you smell gasoline! Your objective is to cautiously determine if the motor turns freely and nothing is wrong versus revving a piece of broken fan into the radiator or onlookers. If the motor does not crank, pull all of the plugs and re-attempt to crank. Beware oil could come shooting out of the plug holes.

Given a trouble-less cranking motor, reconnect the coil, have everyone stand back and attempt to start. Loose parts could come flying! Flooding or fuel pump interlocks are the first things to check if it doesn't start. If she starts, immediately, check the engine gauges and lights, and look for leaks. Then look, listen and approach under the hood carefully for further inspection. A properly running motor leads to the running gear check.

RUNNING GEAR CHECK

Turn the steering wheel slowly lock-to-lock. Listen and check for front wheel turning clearance. Also check the power steering system for leaks. Push real hard on the brakes to see if the pedal sinks. A sinking pedal means bad brakes! And make sure they stop too! Fix them before going any further. Finally, see if the gear shift levers move OK.

MOVEMENT CHECK

Now is the moment of truth — it's time to see if she rolls — on the tires that is! Ease forward as outside observers help with how things sound and look. They are checking for tire clearance, bent wheels, bent drive shafts, dragging brakes and other mechanical malfunctions. Check reverse too.

ADJUST MOVEMENT INTERFERENCE

Remove, bend and adjust interfering body metal and other parts to accommodate vehicle movement. Don't worry about hurting already damaged parts, but do concern yourself with personal safety while realigning the offending pieces. Consider using winches and other mechanical advantage devices to assist with toughies.

Finally, drive cautiously back to camp and perform a more thorough inspection. The sidebar on page 24 lists some useful re-righting tools.

ROLLOVER REVELATIONS

EDITOR'S NOTE: To put our ego aside and tell it how it is, is tough. I'm remembering a time racing around the hills on a motorcycle. I slide off the trail, hit a rock and blew a tire. By the time my friends arrived, the blown tire had caused the fall. Chuck Thompson takes a brave step in sharing how his Truckhaven roll really happened. My belief is he is better equipped for next time, by being honest with himself and us. Given our propensity to protect our egos with fabrications and exaggerations, we deprive ourselves of the real learning experience. Learn from Chuck's honesty!

by Chuck Thompson

Now about the rollover. Although I'm certainly not proud of it, about the best job of ego recovery I can do at this point is to consider it's educational value and try to help out some others. I'll describe not only what and how it happened, but also how I could have prevented it.

There are a whole lot of reasons why it shouldn't have happened; the driver (me) was very experienced, this wasn't an area where any serious side tilt existed, the ground was dry, weather clear, etc. But it did happen...so why? Not surprisingly, it was several things going wrong.

First of all, I lost concentration. We had been traversing a series of steep overpitches, one after the other, and this had become routine enough that I had begun to think of other things and forgot to watch the truck ahead of me to get an indication of which way the trail went on the other side of the pitch. Second, about the time I cleared the top, I suddenly realized that I didn't know which way to go...to the right? To the left? Straight? And that's where I blew it.

At that point, realizing I wasn't sure of where I was on the trail, all I had to do was STOP! While stopped I could have done any number of things to decide what to do and taken all day to do it if I so desired. But I made the mistake of continuing, figuring I would sort it out as I went along. I began a right hand turn (something caused me to think the trail turned to the right; I don't know what it was and it's not important) and then, almost as soon as I began the turn, I saw the trail straighten out in front of me so I turned back to the left to get back on it. What I didn't know at that instant was that my right front wheel had already begun to drop down into a steep gully. The very act of steering back onto the trail, at that point, created the roll. As soon as I realized what was happening, I steered into the roll, but by that time, it was way too late. We pitched over the right front corner of the Toyota, rolled over the passenger side and roof, and then came to rest on the driver's side of the vehicle. There were no injuries and help arrived immediately in the form of Steve Hollen and others.

What's the lesson? What can we learn? When I thought about what I could pass on to others, I wanted to get beyond the usual "pay more attention" kind of stuff. That's all important to be sure, but it isn't very specific. Of course we should be more aware, better prepared, etc. But what about when we're surprised, whether it's right that we should be or not? It goes like this:

Rule Number One: If at any time you don't for sure know where your vehicle is heading, STOP! Don't panic, just STOP! While stopped you can, at your leisure, do any or all of the following:

(a) look around you and see if you can see anything;

(b) ask your right seat passenger what is to the right...trail go that way? Look to the left for yourself. If there isn't any trail to the right or left, then it's a pretty good bet it's going straight ahead....if there is a trail;

(c) get out and use your eyeballs.

Rule Number Two: Secure everything in your truck. In our case we had all our heavy stuff (shovel, hi-lift jack, tools, etc.) well-secured, except for the shackle which Steve Hollen found on the dash and which was responsible for shattering the windshield from the inside. Had we not, we could have turned a simple accident into serious injury. I can't overemphasize this point. Your gear should be stowed assuming there'll be a problem at some point. It's not only good off-road advice, but applies equally well to the freeway. You need to decide which objects you want flying around inside your car in an accident...and then strap the rest down.

Before the 4Runner was righted by hand, the passengers were warned to protect their heads from hitting the window when rolled back, the transmission was put in gear and the brake set.

Once righted, engine fluids were checked and other damage was assessed. Finding none, it was started, straightened out, and then driven on out. Lots of body damage but apparently little else. An experience and a lesson to be remembered.

EDITOR'S NOTE

I have yet to do a complete winching article. What follows is the Winching Class lecture Handout. Without the lecture, the notes will seem a little cryptic, but I feel it is better than nothing.

WINCHING©

By Harry Lewellyn

I) Vehicle Recover Methods
- A) Manpower
- B) Strap, chain, cable, rope
- C) Highlift jack
- D) Winch
  - 1) Types
    - a) Electric
      - i) Frame mounted
      - ii) Portable/receiver type
    - b) Power takeoff (PTO)
    - c) Come-along, hand winch
    - d) Wheel hub
  - 2) Selecting a winch
    - a) One and one-half times Gross Vehicle Weight Rating (GVWR) or 2,000 pounds greater than GVWR
    - b) Battery capacity/type and alternator rating, and condition important too

II) Winch Parts
- A) Hand controller
  - 1) Hard wire remote
  - 2) Wireless remote
  - 3) Dash or other hard wire
- B) Relay (solenoid) box
  - 1) Locate for easy accessibility, and clean deep mud/water operation
- C) Reversible motor
  - 1) Permanent magnet
  - 2) Series wound
- D) Gear reduction
  - 1) Planetary gear
  - 2) Worm gear
  - 3) straight-cut gears
- E) Clutch
  - 1) Allows free spooling of cable for pay out
- F) Drum
  - 1) Receives cable
  - 2) Visible for re-spooling
- G) Brake
  - 1) Keeps drum from turning freely
  - 2) Automatically operates when power is switched off
- H) Cable or wire rope
  - 1) Spools on drum
- I) Cable entrance
  - 1) Hawse
  - 2) Roller fairlead
    - a) Allows angular pulls with less cable friction

J) Forged hook
    1) At end of cable

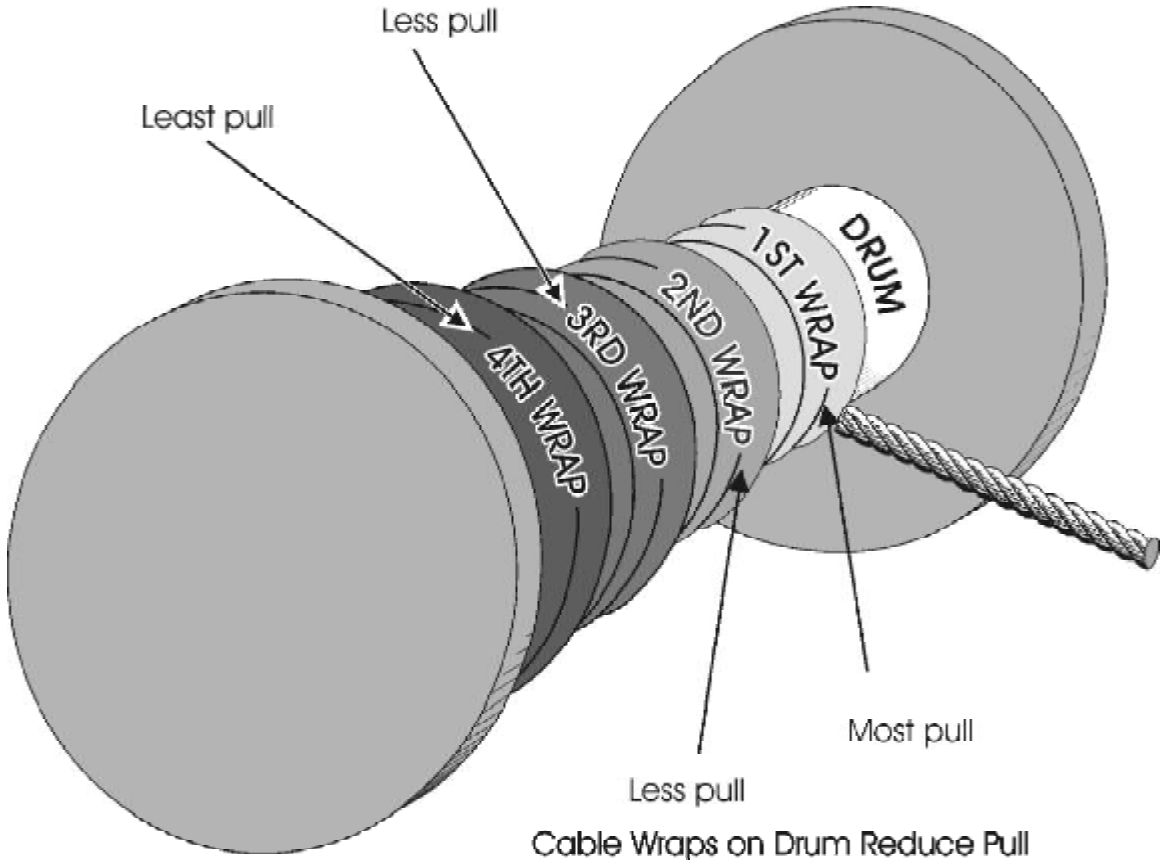
III) Winch Accessories
A) Gloves
    1) Leather working parts at a minimum
    2) Loose fitting best to accommodate quick, easy emergency removal
B) Tree protector strap
    1) Rated at greater than winch pull
    2) Three-inch or greater wide
C) Choker (chain)
    1) Chain hook on one end and slide (slip) hook on other end
    2) Slide hook should fit into oval, DOT, frame, tie-down holes
D) Snatch or pulley block
    1) Rated at twice the winch pull minimum
E) D-shackle or clevis
    1) 3/4-inch or greater pin diameter
    2) Two or more
F) Shovel
G) Hand-saver bar
    1) Used to guide cable or pull hook
H) Large blanket or tarp
    1) I call them a parachute. They minimize accidental dangerous, cable (breakage) movement.
I) Proper vehicle attachment points
    1) Hook, eye, towing receiver hitch or pindle hook - frame mounted only
    2) Never use steering, suspension or stock bumper
    3) Use trailer hitch, with ball attached, with great caution
J) Danforth small boat anchor or artificial deadman
K) Short lengths of lower radiator hose
    1) Position over nylon straps to prevent fraying, cutting or burning

IV) *SAFETY* - Read and heed manufacturers safety instructions
A) No drugs or alcohol use with winch operation
B) No child operators
C) Keep observers outside *DANGER ZONE*
D) Keep hands more than three-feet away from spooling winch cable at fairlead
E) Don't slide cable through hands or over any part of your body
    1) Use hand-over-hand cable technique
F) Never touch, cross, walk over or on tensioned cable
G) Use parachutes (see III-H-1 above) at cable mid-points
H) Raise hood
I) Keep hands and fingers out of hooks
J) Never attach cable hook (or any hook) back onto winch cable
K) Only attach to frame-mounted hardware
    1) Never attach to any vehicle component that moves or has rubber mounting
L) Double check attach points after removing cable slack
M) Inspect cable for kinks, frays or strand separation after removing slack
N) Never release winch clutch when cable is under tension
O) Tape or paint warning indicators near each cable end
P) Use hand-saver to guide cable onto drum or hold hooks
Q) Don't tow with winch cable
R) Winch from within 4X, behind door or at full hand controller wire length away from tensioned winch cable

S) Don't touch hot winch components
T) Set brake, put in gear or park and chock all wheels, on slopes, before removing winch cable support
U) From within, for both pull and towed 4Xs, practice cable break emergency position
    1) Get low and apply brakes in cable breakage emergency

V) Winching Techniques
A) Winch yourself or others
    1) Winch over/past obstacles
    2) Use to get unstuck
B) Read and heed manufacturer's instructions
C) Practice winching techniques under light load, controlled conditions
D) Basics
    1) Regain composure, calm down
    2) Are you really stuck?
        a) Are you in 4WD, hubs locked, proper range and gear, tires at proper pressure
        b) Use alternate track or give up
        c) Check for broken or malfunctioning drive component
        d) Do you have traction
        e) Is undercarriage clear of obstructions
    3) Clear undercarriage obstacles
    4) Clear in front of tires
    5) Choose straight and down hill if possible
        a) Insure freed 4X will not run away, into pull or winching 4X
E) Select recovery method
    1) Manpower
        a) Rebuild road
        b) Hand push
    2) Strap, chain, cable or rope tow by other 4X
    3) Highlift jack
        a) Lift and move
        b) As hand winch
    4) Winch
F) Prepare winch
    1) Un-stow accessories, uncover winch
    2) Inspect winch. accessories, battery connections and cables
    3) Plug in controller
        a) Some consider removing after hook release and prior to actual use
    4) Power out cable to release hook
    5) Release clutch to free spool cable out
G) Select anchor point (in conjunction with H and I below)
    1) Minimize cable angle (see H below)
        a) straight off, and level to ground most desirable
    2) Other vehicle - always occupied with brakes on
        a) Tie-off for additional holding power
        b) Partially bury tires
        c) Use several vehicles in tandem
        d) All vehicles always occupied with brakes on
    3) Mother Nature
        a) Tree
            i) Protect with tree-saver strap
            ii) Put strap low to ground
        b) Rock - very, very big, half-4X size or greater only
            i) Be assured rock will not move downhill into 4Xs

ii) Chain better than strap
iii) Put chain low to ground
c) Downed log or other natural resource
4) Artificial deadman
a) Danforth, small boat anchor
b) Various commercial products
c) Bury spare tire
i) Lugbolt holes at right angle to cable considered best
d) Bury log or rock
e) Use log, rock or spare tire as wedge or chock between large rocks
f) Other man-made resource
H) Select cable direction (in conjunction with G above and I below)
1) Choose straight off drum when possible
2) Choose parallel to ground when possible
a) Consider snatch block to adjust angular pulls of greater than plus or minus 15 degrees off straight
I) Estimate required pull (in conjunction with G and H above and see pages 31 and 32)
1) Easy pull - up to 30% of winch rating - no special requirements - be safe
2) Medium pull - from 30 to 60% of winch rating
a) Pay out some cable for increased pull advantage
i) Cable can be on second or higher drum-wrap
b) Use snatch block for mechanical advantage if desired
i) Cable-in speed will be about half when using one snatch block
c) Use parachute (see III-H-1 above) on all cables, plus other safety practices
3) Hard pull - over 60% of winch rating



Cable Wraps on Drum Reduce Pull

a) Use snatch block *and* as much cable as possible for increased pull advantage
i) Cable-in speed will be about half when using one snatch block
b) Use maximum cable length for increased pull
i) Cable should be down to drum or first wrap
ii) Always leave at least five wraps on drum
c) Use parachutes on all cables and strict adherence to all safety practices

J) Establish anchor
1) Tree
a) Single wrap, at base, with tree protector or flat, nylon strap only
i) Cable, chain and rope kill trees
ii) Multiple, full wraps kill trees
b) Join tree protector (or other strap) end loops with D-shackle
i) Screw pin fully in, then back-off about one-half turn
ii) Put pin-side to strap
2) Rock
a) Single wrap, at base, with chain preferred
i) Cable, rope and flat strap can fray, weaken or be broken by sharp rocks
ii) Protect above with lengths of lower radiator hose
b) Use chain-hook end of choker to make loop
i) Attach chain-hook to chain
ii) Move chain-hook away from D-shackle, pull point
iii) Hook to hook connection may wedge hooks together
c) Attach D-shackle to chain or other loop
i) Screw pin fully in, then back-off about one-half turn
ii) Put pin-side to strap
3) Other anchor or deadman
a) Use similar, safe practices as with trees and rocks above

K) Cable hook-up
1) Never hook winch cable back onto itself
2) Pay out cable
a) Power out short length of cable to release hook
b) Release clutch
c) Grab base of hook and walk out desired length of cable
d) Re-engage clutch
3) Open snatch block and run cable around open pulley roller as required
4) Secure hook
a) Secure hook, open-face up
b) Attach directly to frame-attached connection points only, or
c) Secure hook to D-portion of shackle on tree protectors, chains, straps or deadman

L) Prepare to winch
1) Route hand controller wire away from winch, and preferably, back into winch vehicle via window
2) Gently power-in cable slack with slight winch power
3) Check cable path for friction or obstructions
a) Put wood or logs where cable rubs ground or other obstacles
4) Place parachutes on cables
5) Raise hood on winch 4X as required
a) Raise hood if anchor is also a facing 4X
6) Clear Danger Zone of onlookers
7) Re-inspect attach points, anchors and all connections

M) Winching
1) Seatbelt driver of all participating vehicles
2) Start motor or winching 4X and rev to 1000 RPM above idle
3) Start all participating vehicles for power brake operation

4) Establish communication between all vehicles and operation director
5) Verbally rehearse procedure - who does *what*, *how* and *when*, including potential mishap
6) Give short duration, reel-in, load test
7) Put stuck vehicle in gear and prepare to *cautiously* assist winching
    a) Don't overrun winch cable - can damage winch or 4X
    b) Be prepared to steer and use brakes too
8) Start winching cautiously
9) In gumbo mud, short, sudden, very slight burst of wheel power will sometimes slightly lift vehicle and assist pull
    a) Constant wheel-spin is usually not desired
10) Stop winching if winch stalls for more than 15-seconds
    a) Winch stall is indicated by: sound, no 4X movement or discharge, battery gauge indication
    b) Hand control operator may need to be told by others of stall
11) Stop winching if winch looks, smells or feels hot
    a) Allow to cool or cool with water
12) Stop and check for cable pile-up on angular pulls
    a) Secure 4Xs, un-spool and re-spool as needed
    b) Re-spool must be tight enough to support next layer
13) Continue winching only if successful
    a) Stop at predetermined, un-stuck position
14) At conclusion of winching, secure all vehicles from undesirable movement
    a) Don't let it roll back into stuck

N) Winch tricks - consider these as applicable
1) Rig to pull stuck 4X slightly up and over/off obstacles
2) Run cable back under the 4X with the winch
    a) Block cable contact/friction points
3) Use winch to remove/move obstacles
4) Butterfly cable on bumper or grille guard, when anticipating reuse, but secure loops and ends from dislodging and dragging while moving
5) Deep cycle batteries do not provide massive, cold cranking amps required of winches

VI) Maintenance

A) Store winch accessories in safe, clean place
B) Re-spool cable in smooth layers under relatively light load to produce tight layers
C) Don't tighten hook too tight
D) Periodically, fully spool out cable, clean with wire brush and kerosene, and inspect
E) Periodically top off gearbox oils
F) Check battery and charge system too

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SUPERWINCH® THEORY OF WINCHING

To get the best from your winch and equipment requires some understanding of the mechanics involved in winching. For winching purposes the resistance to motion of a vehicle is dependent on 4 main factors:

(i) the inherent resistance to movement of the vehicle
(ii) the total weight of the vehicle
(iii) the nature of the surface to be crossed
(iv) the gradient up which the vehicle is required to be moved

(i) The inherent resistance of a vehicle depends on the state of the tyres, friction in the drive-chain (which will cause drag), the weight of the vehicle, and whether the vehicle has sustained any damage to its running gear.

For our purposes, we will assume that the vehicle is in good working order and has all tyres inflated to the recommended pressures - a flat tyre will cause considerable drag, and it may be advisable to change a tyre that is deflated before commencing recovery operations.

(ii) The weight of the vehicle includes all equipment, luggage, fuel, passengers and stores, etc. aboard the vehicle.

(iii) The nature of the surface to be crossed is the largest variable in the winching equation. A vehicle in good running order on a metalled surface will only require a force of about 4% of its total weight to induce motion, whereas a vehicle to be recovered from a bog will require a pull equivalent to about 50% of the total weight of the vehicle. The table below shows that different surfaces require proportionate efforts to produce vehicle movement.

Type of Surface	Coefficient of resistance of surface to be crossed
Hard metalled road	0.04 times total weight of vehicle
Grass	0.143 times total weight of vehicle
Sand (hard wet)	0.167 times total weight of vehicle
Gravel	0.2 times total weight of vehicle
Sand (soft wet)	0.2 times total weight of vehicle
Sand (soft dry/loose)	0.25 times total weight of vehicle
Shallow mud	0.33 times total weight of vehicle
Bog	0.5 times total weight of vehicle
Marsh	0.5 times total weight of vehicle
Clay (clinging)	0.5 times total weight of vehicle

A simple calculation will show that approximate rolling resistance of an undamaged vehicle on a flat surface can be predicted e.g. the pull required to move a vehicle weighing about 4500lbs along a flat sandy beach of hard, wet sand.

weight of vehicle (lbs) X coefficient of surface to be crossed = 4500 lbs X 0.167 =(about) 750 lbs

However, as all surfaces are not flat, the calculation must therefore include the gradient resistance coefficient.

(iv) Gradient Resistance: The gradient up which a vehicle is to be moved may only cover a short distance, over the total distance of the pull, e.g. a ditch or rock, or it may cover a long climb up a hill. Even for a relatively short upward pull, gradient resistance must be taken into account. For practical winching purposes, gradient resistance can be taken as a 1/60th of the weight of the vehicle for each degree of the slope, up to 45-degree incline.

continued

$$\frac{\text{gradient weight X weight of vehicle}}{60}$$

e.g. for a 15 degree slope, gradient resistance will be 15/60 of the weight of the vehicle, which is 1/4 the weight of the vehicle. For inclines over 45 degrees, for safety reasons, the gradient resistance should be assumed to be equal to the total weight of the vehicle. That the slope to be negotiated to all intents and purposes is only 1ft high will make no difference to the calculations, and should be considered when pulling the vehicle over ridges. If we combine the weight of the vehicle, the type of surface to be crossed and the gradient to be overcome we get the calculation.

$$\text{weight of vehicle X coefficient} + \frac{\text{gradient weight X weight of vehicle}}{60}$$

Therefore the winching formula is:

$$(W \times C) + \frac{(G \times W)}{60} = \text{effort required}$$

Where: W = Weight of vehicle
C = Coefficient of resistance of surface to be crossed
G = Angle of gradient (in degrees)

i.e. Vehicle weighing 4,500lbs is to be winched up a sand dune of dry loose sand with a slope of 15 degrees.

Using the winching formula above

Where: W = 4500 lbs (vehicle weight)
C = 0.25 (coefficient for soft dry / loose sand)
G = 15 (slope in degrees)

We have:
$$(4500 \times 0.25) + \frac{(15 \times 4500)}{60} = 1125 = 1125$$

= 2250 lbs effort required to recover vehicle under these circumstances

If we substitute clinging clay for the surface (coefficient of 0.5) and 35 for the gradient (slope) in the above equation we get:

$$(4500 \times 0.5) + \frac{(15 \times 4500)}{60} = 4875 \text{ lbs effort required}$$

The effort required may be outside the capacity of the winch, (the rating of a winch usually refers to the first layer of wire rope on the drum). In this case, one solution may be to run out most of the winch cable to enable the winch to be used at or near its rated capacity, or introduce a pulley block pulley in the winch line to create a mechanical advantage, thus practically halving the effort required by the winch.

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