Verde Valley 4 Wheelers Guide Sheet

4WD Vehicle Winching Strength Margins

Purpose:

The purpose of this Guide Sheet is to explain why winches designed for Jeeps and other 4-wheel drive vehicles must be operated more carefully than we might expect. This is not a winching how-to; other documentation is available for that.

The Short Version:

- Winches, winch lines and rigging for 4-wheel drive (4WD) vehicle recovery are small, light and easy to use. The downside is they have much less strength margin than other winching and rigging equipment. There is much less strength margin in winch lines in particular, whether they are wire rope or high-strength synthetic.
- A parting winch line can whip around with substantial energy and people can be injured. Great care must be taken using a 4WD winch. That includes inspecting the line and rigging before and after use, keeping all non-essential people a safe distance away, and keeping the operators in a position where they are unlikely to be struck and injured by parting lines.
- Older winch lines, deteriorated by sun damage, corrosion, normal use and mis-use may no longer be strong enough to withstand the maximum pull of the winch, so they can break in normal use. That must not happen and is why inspection is so important.
- Wire rope and synthetic line each have their own characteristics, advantages and disadvantages, yet both have similar breaking strength when new.
- Synthetic rope is considered somewhat safer than wire rope if broken under tension. However, because of the risk of injury, it must be considered absolutely unacceptable for any winch line to break in normal use, just like it is unacceptable for the wire rope on cranes or on elevators in tall buildings to break. 4WD winch lines do occasionally break however. Read on to find out why.

Know More:

- Unlike 4WD winches, commercial winches are designed with a safety factor of 4 to 1 or 5 to 1, depending on the design standards used. This means all winch components, including the winch rope, must be able to handle 4 or 5 times the rated load.

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- For either a 4 or 5 to 1 safety factor, a 10,000 lb rated winch should be using 3/4-inch diameter rope which has a breaking strength of around 50,000 lb when new. A 12,000 lb winch should be using 3/4-inch diameter line (for 4 to1) or 7/8 inch diameter line to meet a 5 to 1 safety factor.
- 4WD winches big enough for 70 or 80 feet of 3/4 or 7/8-inch line would be large, heavy and impractical. Compromises have been made by manufacturers so the winches can be smaller, lighter and easier to use. The compromises reduce safety factors considerably, so the reality is, extreme caution must always be exercised when using a 4WD winch.
- 10,000 lb and 12,000 lb 4WD winches most commonly ship with 3/8-inch line which has a breaking strength of around 16,000 lb when new (a range of 14,400 to 17,000 lb). This provides a safety factor of 1.2 to 1.7 for those winch sizes. That is very little safety margin, and it becomes less with age and use.
- *Ensuring your winch line is always in near-new condition is the best way to keep from breaking a line in normal operations*.

Read More:

Rigging for 4WD Winching:

- The most common winch line pull ratings for offroad vehicles like our Jeeps, Toyotas and others are 10,000 lb or 12,000 lb, but there are others as well, ranging from 9,500 lb to 13,500 lb.
- Line pull ratings on 4WD winches are marketed as the maximum line pull that can be generated by the winch on the bottom layer of rope on the drum. Line pull on higher layers is somewhat less.
- Fortunately, most recovery winch pulls are relatively light, less than half the winch rating. Winch performance and rigging safety are better under those conditions. Pre- and post-use inspections and watchful caution are still needed even for light pulls.

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- Heavier loads, above 1/2 the winch rating reduce strength margins and consideration should be made for 2 to 1 roping using a snatch block to reduce line pull at the winch. Remember, when roped 2 to 1, the shackle connecting the snatch block to the other rig will see two times the winch load. Plan accordingly.
- When the load is very high and the winch motor is straining and close to stalling, the small diameter 4WD winch line has low strength margin and extreme caution must be used. Non-essential people need to clear the area and those involved should avoid places the line could go if it parts.

Information About Shackles:

- The most common shackles we've seen on Jeeps, etc. are 3/4-inch screw-pin anchor shackles, although we have seen 5/8-inch shackles as well.

Screw-pin anchor shackle
The bow diameter is the size. The screw pin is always 1/8-inch larger diameter in 4WD shackle sizes. Shackles are marked with size and working load limit (WLL), so, for example, a "rated" 3/4-inch shackle will be marked "WLL 4-3/4T" and this means the working load limit is 4-3/4 tons or 9,500 lb.

- "Rated" screw-pin anchor shackles have the working load limit (WLL) or sometimes safe working load (SWL) marked on them. *Never use an unmarked (un-rated) shackle, they could be half as strong or less.* Shackles also have a proof load, which is a sampling test the manufacturer does during a production run. The shackle must not permanently deform during the proof test. And finally, they have a minimum breaking strength which is five-times the working load limit.

Shackle Size	WLL	Proof Load	Min. B.S.
5/8-inch	6,500 lb	14,300 lb	32,500 lb
3/4-inch	9,500 lb	20,900 lb	47,500 lb
7/8-inch	13,000 lb	28,600 lb	65,000 lb

Reference: Federal Specification RR-C-271

A 5/8-inch shackle could deform if the winch line breaks at 16,000 lb. And if it's used on a snatch block, the breaking strength is about the same as the two parts of line. If the shackle fails, the snatch block could be flying around causing severe damage or injury. *Never use a 5/8-inch shackle on a snatch block.*

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A 3/4-inch shackle will not permanently deform if a 16,000 lb line fails. It will not fail if breaking 2-parts of 3/8-inch line on a snatch block.

A 7/8-inch shackle will not fail, and likely will not deform permanently if breaking 2-parts of 3/8-inch line on a snatch block. A 3/4-inch shackle will not break either, but could permanently deform under those conditions.

- It is not clear if standards are being developed for soft shackles. A review of websites indicates soft shackles for 4WD use can have an advertised breaking strength ranging from 31,000 lb to 56,000 lb. Most are unmarked. Safe working load is rarely discussed and sometimes the breaking strength is not mentioned either. We believe soft shackles can be used cautiously if the strength and condition are known and meet the needs of the task at-hand.

Things We Do Not Know:

- 4WD winch manufacturers do not tell us how hard their winches will actually pull when in as-new condition. They say the rating is what the winch will pull on the bottom layer on the drum, but manufacturers do not want to be caught with a winch that pulls less than the rating. They most likely build in a margin above the rating. We just don't know how much. And that margin reduces the safety factor of the winch line, which is already much lower than common standards.
- Working load limits or safe working loads are not published for 4WD winch lines, either for new winches or for replacement lines. Breaking strength is sometimes but not always disclosed.
- We know very little about the static and dynamic capability of winch brakes.

Now, This Important Message:

Licensed crane operators, riggers and winch operators will never consider breaking strength. The only thing they go by is working load limit or safe working load of everything used in their rigs. They never exceed the working load limit of wire rope, straps, shackles, hooks, chains, spreader bars or other components.

The 4WD world is very different, with much less safety margin and mostly untrained operators. Off-roaders need to understand everything they're using when winching because of the risk of injury to themselves and others.

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Wrap-up questions you may have:

- **Why inspect before *and* after use?** Good question. We inspect after to ensure no damage occurred to the line during use, and to give us time to order a replacement line if needed. We inspect before use to make sure nothing happened between off-road adventures. For example, an angry person in a parking lot can do a lot of damage to your synthetic line top layer with a quick swipe of a pocket knife.
- **Why do any rigging systems need a 5 to 1 safety factor?** Safety standards are written in blood. Human nature has caused countless failures, injuries and deaths in 180 years of using wire rope and 30 years of using high strength synthetic lines. Operators might think it's ok to overload a system, or it's ok to use that old rope even if it has some corrosion and broken wires in the strands. Maybe they forget to consider shock loads. If they got away with it last time they may think it'll be ok this time. By the way, some rope systems require a 10 to 1 design factor, such as handling nuclear weapons or people. When it is absolutely, positively unacceptable to drop a load, our history teaches us we need these even-higher strength margins.
- **Should I be switching to 7/8-inch shackles for everything?** For off-road use, 3/4-inch shackles are generally strong enough, but maybe not in unusual applications. You'll have to decide. Vehicle attachment points and snatch block connections are usually sized for 3/4-inch shackles, and 7/8-inch shackles sometimes just won't fit. If 7/8-inch shackles will work in your system, feel free to go for it, but you might not be able to use one on the rig you're pulling out.
- **What else do I need to know?** Here's a link to a Warn Industries Basic Guide to Winching Techniques
- **Who wrote this Guide Sheet?** It was written by a mechanical engineer with 40 years experience designing, developing, testing, installing and supporting larger winches and rigging systems. If you have questions or comments you may contact him directly: Chuck Boyle, *winchdoctor@yahoo.com.*