



JEROME E. SPEAR



MIKE RANDALL

# SAFE USE OF WIRE ROPE

Proper maintenance and inspection.

**"A** chain is only as strong as its weakest link" is an often-used cliché frequently spoken or written in a figurative context.

Although not a chain, wire rope is often an integral part of many pieces of load handling equipment. A failure to any "link" used in load handling equipment, including wire rope, can have catastrophic consequences . . . literally.

Wire rope comes in different sizes and construction, which affects its breaking strength. However, its breaking strength is dependent on its overall condition. Like any equipment part or system, proper maintenance, inspection, and use are critical in maintaining the equipment in safe operating condition.

When evaluating a wire rope's safe working condition, the following questions should be considered:

- What factors can affect a wire rope's breaking strength?
- How frequently should wire rope be inspected?
- What removal criteria should be used?

## Wire Rope Construction

Wire rope is made of steel wires laid together to form a strand. These strands are laid together to form a rope, usually around a central core of either fiber or wire. The number of strands, number of wires per strand, type of material, and nature of the core all depend on the intended purpose of the wire rope.

**Problems such as wear, metal fatigue, abrasion, corrosion, kinks, and improper reeving have more importance in dictating the life of a wire rope than the breaking strength factor based on new rope condition.**

Wire rope that has many smaller wires and strands is more flexible than rope with larger-diameter wires and fewer strands. Wire rope that is used with sheaves and drums should have many strands to be flexible enough to bend around the sheaves and drums.

Wire ropes are classified by grouping the strands according to the number of wires per strand. The number of wires and

the pattern define the rope's characteristics. The more wires in a strand, the more flexible the wire rope.

Likewise, the more strands in the rope, the more flexible the rope. However, the more strands in a rope and more wires in a strand, the less resistant the rope is to the crushing effects of abrasion and crushing.

Other important requirements to consider when selecting a wire rope are the breaking strength and safe working load. These values can be found with the use of a chart. Wire rope has a design factor from 2.5 to 8 depending on its application, usage, and rope type.

For example, a load hoist rope on a mobile crane comprised of a "standard" rope (i.e., non-rotation-resistance rope) has a minimum design factor of 3.5. That is, the safe working load for this type and use of rope would be based on a safety factor of 3.5 (i.e., the rope breaking strength divided by the safety or design factor equals the safe working load of the rope).

Although wire rope can be made with a wire core, most have a fiber core that is saturated in oil and helps keep the rope lubricated. The purpose of a fiber core is to support the outer strands of the wire rope and is not included when calculating the minimum breaking force.

Wire rope is lubricated during the manufacturing process. This provides the rope with protection for a reasonable time if the rope is stored under proper conditions. When the wire rope is in service, the initial lubrication will not be sufficient to last the lifetime of the rope. Therefore, it is usually necessary to apply a lubricant to a wire rope under working conditions. A light mineral oil can be used for lubrication. Never use old crankcase oil.

## Wire Rope Inspection

Wire rope inspections are important checks on any type of rigging equipment. Problems such as wear, metal fatigue, abrasion, corrosion, kinks, and improper reeving have more importance in dictating the life of a wire rope than the breaking strength factor based on new rope condition.

As a result, wire rope should be regularly inspected in accordance with OSHA and industry standards. The frequency of wire rope inspections should be based on such factors as rope life on the particular installation or similar installations, severity of environment, percentage of capacity lifts, frequency rates of operation, and exposure to shock loads.

However, running rope in service is to be visually inspected daily. OSHA requires an inspection of wire rope to be conducted each month. In addition, OSHA requires wire ropes used on equipment is to be inspected by a qualified person at least every 12 months.

Wire rope should be inspected for the following conditions.

### Is there a reduction in diameter?

Any new wire rope will stretch when the initial load is applied. After the initial stretch and a slight stretching over time during normal wear, the rope will begin to stretch at a quicker rate, which means it is approaching the time for replacement.

Any noticeable reduction in diameter is a serious deterioration problem. A wire rope is measured across its diameter at its widest point. Diameter reduction could be caused by one or a combination of faults. In general, wire ropes should be replaced when the diameter reduction is more than 5% from the nominal diameter.

### Is there distortion of the rope structure?

Distortion of rope structure includes kinking, severe doglegs, birdcaging, and crushed strands. Criteria to remove the rope include steel core protrusion between the outer strands, kinking, severe doglegs, and changes in the original geometry due to crushing where the minimum dimension across the distorted section is less than or equal to 5/6 of the nominal diameter.

Crushed strands are a result of too many layers of rope wrapped around a drum. In general, there should be no more than two layers of wire rope on the drum, especially if the rope is a type with many small wires (such as 6 × 37).

Crushing also occurs by cross winding, which is a result of poor winding procedures. This is generally related to improper fleet angle, which is between the rope's position on a drum or sheave and the line drawn perpendicular to the axis of the drum or sheave through the center of the nearest fixed sheave.

Kinks are permanent distortions. After a wire rope is kinked, it is impossible to straighten the rope enough to return it to its original strength. If a rope cannot be unkinked by hand, the wire rope should be removed from service.

Birdcaging condition is a torsional imbalance, which is a result of mistreatment such as pulling through tight sheaves, wound on too small a drum, or sudden stops.

### Is there visible corrosion?

This problem is difficult to evaluate, and it is also much more serious than normal wear. Corrosion will often start inside the rope before it shows on the outside. A lack of lubrication is usually the cause. Wire pitting or severe rusting should be cause for immediate replacement.

Excessive waviness of wire rope (indicating that the rope should be removed from service) is when the overall envelope diameter has increased to a value greater than 110% of nominal rope diameter.

### Is there heat damage?

Removal criteria include any apparent damage from a heat source such as welding, power line strikes, or lightning. Wire rope that has been inadvertently (or purposely) used as a ground in welding or has been in contact with a live power line will have fused or annealed wires and must be removed from service.

In addition, removal from service is warranted when a strand is higher or lower than half of the strand's diameter above or below the surface of the rope.

### Is there damage to the end terminations?

Severely corroded, cracked, deformed, worn, grossly dam-

### More on Wire Rope

Read more on the safe use of fiber and wire ropes at [waterwelljournal.com/safe-use-of-fiber-and-wire-ropes](http://waterwelljournal.com/safe-use-of-fiber-and-wire-ropes), or scan the QR code and search "Wire Rope" on *Water Well Journal's* website.



SCAN TO VIEW

aged, or improperly installed end terminations are included in the criteria to remove wire rope from service.

### Are there too many broken wires?

Finding one broken wire (or several widely spread) is usually not a problem. Regular breaks are a cause for concern and require closer inspection. A rope lay, as a unit of measurement, is used when determining if a wire rope should be replaced due to visible broken wires.

Criteria for rope replacement due to broken wires are as follows:

- **Running wire ropes:** Six randomly distributed broken wires in one rope lay or three broken wires in one strand in one rope lay, where a rope lay is the length along the rope in which one strand makes a complete revolution around the rope.
- **Pendants or standing wire ropes:** More than two broken wires in one rope lay located in the rope beyond end connections and more than one broken wire in a rope lay located at an end connection.
- **Rotation-resistant ropes:** Two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters.
- **Slings:** Ten randomly distributed broken wires in one rope lay or five broken wires in one strand in one rope lay. For construction worksites, wire rope shall not be used if, in any length of eight diameters, the total number of visible broken wires exceeds 10% of the total number of wires, or if the rope shows other signs of excessive wear, corrosion, or defect.
- **Valley breaks:** A valley break is a wire break that occurs at or below the strand-to-strand contact points. Wire ropes with valley breaks should be removed from service.

### Conclusion

Wire rope is an integral part of many pieces of load handling equipment. Like any equipment part or system, proper maintenance, inspection, and use are critical in maintaining the equipment in safe operating condition.

Wire rope is never good forever, and it is important for the end user to know when the rope's condition indicates the need for the rope's removal from service. A failure to any part of load handling equipment can be fatal. [www.wwj.com](http://www.wwj.com)

---

**Jerome E. Spear, CIH, CSP, FAIHA**, is president and founding partner at forensic consultants Spear & Lancaster, which is located in Magnolia, Texas. They provide expert safety, process safety, and industrial hygiene consulting. He can be reached at [jerome.spear@jespear.com](mailto:jerome.spear@jespear.com).

---

---

**Mike Randall, CSP**, has more than 35 years of experience in the health, safety, and environmental (HSE) field, working in the oil and gas, petrochemical, manufacturing, modular fabrication, power, and construction industries.

---