



U.S. Department of Labor  
Occupational Safety and Health Administration  
Directorate of Technical Support & Emergency Management  
Office of Science and Technology Assessment

## Working Safely with Wire Rope

Safety and Health Information Bulletin

SHIB 01-19-17

### Introduction

Recent OSHA investigations found several workplace incidents involving wire rope failures, often resulting in worker fatalities. These ropes consist of multiple strands of concentrically wound wire, and degradation in only one strand may result in an unexpected break of that strand and an abrupt release in rope tension. When rope tension is lost, the load it is holding or the machine it is controlling may fall or move. Because the movement is unpredictable, workers are at risk for crushing and struck-by injuries. Understanding how wire rope is structured, what causes degradation, what to look for when inspecting ropes, and how often to inspect them assists in the prevention of both wire rope failure and worker injuries and fatalities.

### About Wire Rope

*What is wire rope?*

A wire rope has three components – wires, strands, and the core (Figure 1). Wires, the smallest component, are single, continuous lengths of metal, usually steel. Strands are made by twisting the wires in a spiral (i.e., helically). Strands are then wrapped around a core, typically fiber, steel, or another strand, to give the rope support and flexibility. Therefore, a

This Safety and Health Information Bulletin is **not** a standard or regulation, and it creates no new legal obligations. The Bulletin is advisory in nature, informational in content, and is intended to assist employers in providing a safe and healthful workplace. Pursuant to the *Occupational Safety and Health Act (OSH Act)*, employers must comply with hazard-specific safety and health standards and regulations promulgated by OSHA or by a state with an OSHA-approved state plan. In addition, pursuant to Section 5(a)(1), the General Duty Clause of the Act, employers must provide their employees with a workplace free from recognized hazards likely to cause death or serious physical harm. Employers can be cited for violating the General Duty Clause if there is a recognized hazard and they do not take reasonable steps to prevent or abate the hazard. However, failure to implement any recommendations in this Safety and Health Information Bulletin is not, in itself, a violation of the General Duty Clause. Citations can only be based on standards, regulations, and the General Duty Clause.

wire rope is essentially numerous metal strands spiraled around the wire core.

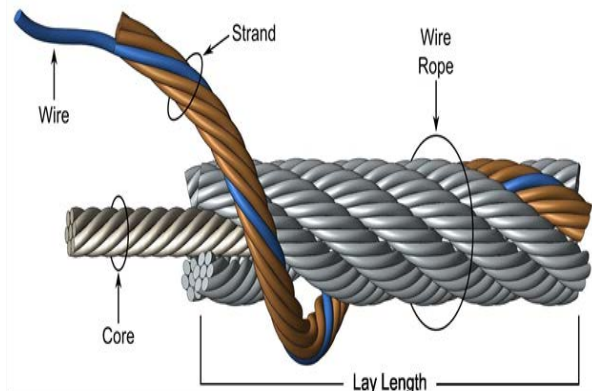
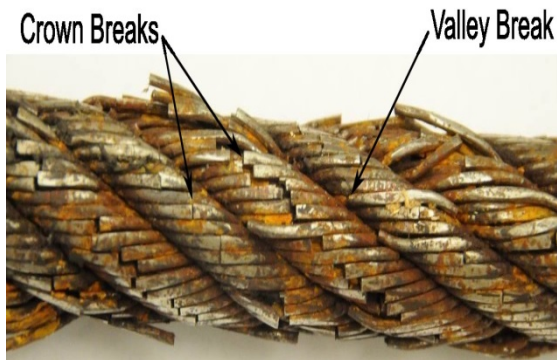


Figure 1: Wire rope components.  
Created by Phillip Toone, OSHA DTSEM/SLTC

*What causes wire rope degradation and failure?*

Wire ropes used for hoisting, lowering, and horizontally moving suspended loads are subject to high tensile stress and degradation through wear and corrosion. All wire rope components degrade over time in service but the degradation rate depends on several variables. For example, the degradation rate depends on how often the load limit is exceeded, cyclic loading history, proper periodic maintenance and lubrication, abrasive service history, core/rope design and weather/chemical exposure.

When a wire rope's structural components degrade, the rope may fail under load. Wires may degrade and break on the outside of a strand (i.e., a "crown break") or break where the wire wraps into the underside of a strand (i.e., a "valley break") (see Photo 1). Degradation occurs in the outward facing wires and in the internal or core wires.



*Photo 1: Crown breaks with square terminations typical of fatigue.* Photo by: Daniel T. Crane, OSHA/DTSEM/SLTC

Degradation in the outward facing wire is caused either by fatigue or tensile failure. Fatigue failure results from repeated cyclic loading such as bending, tension, and torsion. Tensile (i.e., "pulling apart") failure

results from too much load stress. Both fatigue and tensile failure can occur in individual wires, strands, or the entire wire rope. OSHA's construction cranes standard provides criteria for removing a running wire rope from service. As detailed in 29 CFR 1926.1413(a)(2)(ii)(A)(1), wire rope should not be used when it exceeds six breaks in multiple strands in any lay length or three breaks in any single strand in any lay length. Lay length is the distance for a strand to wrap around the core. OSHA also has requirements for removing wire rope slings used in general industry, 29 CFR 1910.184(f)(5), and wire rope used in maritime industries, 29 CFR 1919.79.

Wire ropes will also experience fatigue breaks from degradation in the internal or core wires. These breaks are generally not visible using normal, non-destructive inspection techniques. Fatigue breaks in a slack rope will sometimes "crackle" when bending. However, this is not a test that can or should be performed on a wire rope that is in service. Proper periodic lubrication will help prevent internal degradation as the internal wires slide when the rope bends.



*Photo 2: A portion of the failed wire rope section showing an excessive number of fatigue breaks in any length.* Photo by: Daniel T. Crane, OSHA/DTSEM/SLTC

### *How are wire ropes inspected?*

Wire rope has a finite service life and therefore requires consistent, thorough, and documented inspections to identify component degradation before a failure. Conducting periodic inspections, as recommended by the manufacturers, is the most effective way to detect, monitor, and respond to wire fatigue failures. Sensors, such as acoustic emission and electromagnetic, can detect wire rope degradation; however, physical inspections are the most effective method. Inspections should cover all wire ropes in a system to include the boom hoist, jib, and auxiliary.

Because the stresses are typically greatest at the periphery or outside surface, fatigue breaks on the crown of a strand can be identified on a properly cleaned rope through visual inspection with the naked eye or a low-power magnifying glass. Equipment design should facilitate the ability to visually inspect the wire rope along its entire length. Inspections should use methods that will identify degradation in external and internal wires.

Detailed inspection requirements are described in the OSHA standards, industry consensus standards, and the manufacturer's instructions. Wire ropes in general industry service must comply with 29 CFR 1910.179, 29 CFR 1910.180, and 29 CFR 1910.184, as applicable. Wire ropes used in the construction industry must comply with 29 CFR 1926.251, 29 CFR 1926.1413 and 29 CFR 1926.1414, as applicable. The direction provided in these standards is the minimum requirement and should be augmented with industry consensus standards, such as ASME B30.5-2004 Mobile and Locomotive Cranes; ASME B30.9-2-2014 Wire Rope Slings: Selection, Use, and Maintenance; and manufacturers' instructions.

Additionally, the [OSHA Safe Sling Use](#)

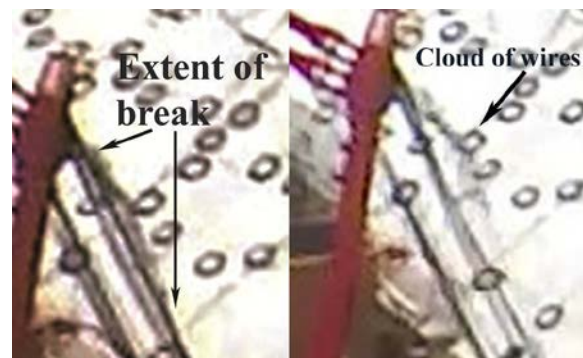


*Photo 3: Wire rope failure location in the lattice boom crawler crane.*

webpage contains useful information.

### **Case Study – A fatality took place after a crane's boom hoist wire rope failed and dropped the boom and load onto workers.**

In May 2013, two workers working under the boom and load were killed when the wire rope on a crawler crane failed catastrophically. OSHA's Directorate of Technical Support and Emergency Management's Salt Lake Technical Center analyzed rope samples from the section that failed and determined that most of the wires in the rope were already broken from fatigue before the incident occurred (Photo 2). The flat or 'squared' ends in the individual



*Photo 4: Close up at moment of wire rope failure captured from surveillance video*

broken wire fractures indicated there was fatigue failure. The thinning or 'necked' geometry at the end of the broken wires also indicated there was tensile failure in the wire.

It is likely that six years of loading and bending made the individual wires in the rope more brittle (i.e., metallurgical work hardening) before fatigue and tensile failure occurred. Numerous brittle wires in the rope broke over time and the remaining wires were unable to carry the load failure. Photos 3 and 4, above, show two sequential still images from a surveillance video as the rope broke. The wire "cloud" in the picture on the right shows the impact tensile forces have on loaded wire rope, producing a cloud of short wires when it fails. For perspective, the load at the time of the incident was a fraction of the factory-rated load for this wire rope. Proper rope inspection and maintenance could have prevented the loss of these workers' lives.

### *What standards apply?*

Specific OSHA standards that apply to wire rope inspection include:

- 29 CFR 1926.251, Rigging equipment for material handling
- 29 CFR 1926.1413, Wire rope-- inspection
- 29 CFR 1926.1414, Wire rope-- selection and installation criteria
- 29 CFR 1910.179(m), Overhead and gantry cranes - Rope Inspection
- 29 CFR 1910.180(d)(6), Crawler locomotive and truck cranes - Inspection records
- 29 CFR 1910.184, Slings - Wire rope
- 29 CFR 1919.79, Wire rope
- ASME B30.5-2004, Mobile and Locomotive Cranes
- ASME B30.9-2-2014 Slings: Safety

Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings

### **How OSHA Can Help**

OSHA has Compliance Assistance Specialists (CASs) located in many OSHA offices throughout the nation who can provide information to employers and workers about OSHA standards, short educational programs on specific hazards, or OSHA rights and responsibilities, as well as information on additional compliance assistance resources. Contact your local OSHA office for more information. Please contact your nearest OSHA Regional Office to locate a CAS close to you.

OSHA's On-site Consultation Program offers free and confidential occupational safety and health services to small and medium-sized businesses in all states and several territories, with priority given to high-hazard worksites. On-site Consultation services are separate from enforcement and do not result in penalties or citations. Consultants from state agencies or universities work with employers to identify workplace hazards, provide advice on compliance with OSHA standards, and assist in establishing and improving safety and health programs. To locate the OSHA On-site Consultation Program nearest you, call 1-800-321-6742 (OSHA) or visit [www.osha.gov/dccsp/smallbusiness/index.html](http://www.osha.gov/dccsp/smallbusiness/index.html).

### **Workers' Rights**

Workers have the right to:

- Working conditions that do not pose a risk of serious harm.
- Receive information and training (in a language and vocabulary they understand) about workplace hazards,

methods to prevent them, and the OSHA standards that apply to their workplace.

- Review records of work-related injuries and illnesses.
- Receive copies of results from tests and monitoring done to find and measure hazards in their workplace.
- File a confidential complaint with OSHA to have their workplace inspected if they believe there is a serious hazard or that their employer is not following OSHA's rules.
- File a complaint with OSHA if they have been retaliated or discriminated against by their employer as the result of requesting an inspection or exercising any of their other rights under the OSH Act.

### **Contact OSHA**

For questions or to get information or advice, or to report an emergency, report a fatality or catastrophe, order publications, sign up for OSHA's e-newsletter *QuickTakes*, or to file a confidential complaint, contact your nearest OSHA office, visit [www.osha.gov](http://www.osha.gov), or call OSHA at 1-800-321-OSHA (6742), TTY 1-877-889-5627.

Twenty-eight states and territories operate their own occupational safety and health State Plans approved by OSHA. State Plans may have different or additional requirements. A list of State Plans is available at: <http://www.osha.gov/dcsp/osp/>.