Wire Rope Inspection/Retirement Information for API RP-9B

Inspection Requirements

Inspection requirements are typically based on the application in which the wire rope is used. On the same site, a drilling line will have different requirements than operating ropes in other applications or than stationary ropes used for structural purposes. The following will provide information on various aspects of inspection and some basic removal criteria to use if no other sources are available.

Inspection Frequency

There are typically two or more types of inspection. The most frequent inspections are for the most obvious damage and are less detailed. The less frequent inspections are more detailed and typically require that the results of the inspection be recorded and kept.

Daily visual inspections, which are done prior to operating the equipment, are to detect obvious signs of deterioration, significant changes in the wire rope’s condition, to observe areas that have previously been identified as approaching removal criteria and to verify proper rope reeving and spooling on the drum. This is typically an inspection by the equipment operator at the beginning of each shift and is recorded on a checklist as completed.

Monthly inspections are much more detailed and are of the entire length of the rope. They are to detect progression of normal wire rope wear as well as locating areas of damage or abuse in the wire rope. These will include measurements of the rope’s diameter, counting of broken wires in the area of heaviest concentration, examining the wire rope at expected wear locations, looking for damage to the wire rope structure and checking for corrosion. The signed, dated inspection report for this inspection is to be filed with the equipment’s maintenance records.

Note: Any time a rig is moved to a new location, a ‘monthly’ inspection must be done on all wire ropes immediately prior to the rig being placed in service. With the tear down, transportation and subsequent reinstallation of wire ropes on a rig there are many opportunities for wire rope to be damaged or improperly installed, thus necessitating the detailed inspection.

Yearly inspections that are conducted by an outside third party inspection firm may be required in some applications or by regulatory bodies. The inspection report from the third party inspection firm is to be filed with the equipment’s maintenance records.
Common types of wire rope deterioration – this is not an exhaustive list, but a description of some commonly encountered types of wear and deterioration.

Wire wear - There are two type of wire wear that cause flattening of the wires on the surface of the wire rope when it contacts objects. In both cases, the harder the object that the wire rope contacts, the more rapid and significant is the damage that occurs.

Abrasion – Abrasion causes a flat wire surface by wearing away the circular crown of the wire due to the wire rope’s sliding contact with another object.

Peening – Peening causes a flattening of the wire surface by metal movement due to the wire rope impact or ‘slapping’ against another object.

Broken Wires – Broken wires are an important indication of wire rope condition. There are different types of wire breaks and different causes for each of them. All wire breaks have the same effect of lowering the remaining strength of the rope, but because of the difficulty in detecting valley wire breaks there is more stringent removal criteria for valley breaks. Following are descriptions of the most common types:

Crown wire breaks – Crown wire breaks occur on the top of the strands on the outside of the wire rope and are normally related to fatigue or fatigue in combination with wear on the wires. These are easily discernible in a wire rope inspection. These may occur with little or no wire wear or in wire ropes showing heavy wire wear.
_Valley wire breaks_ – Valley wire breaks occur at the contact points with adjacent strands or with the core of the wire rope. The origination of valley breaks is normally associated with nicks that were created in the wire from the high contact stresses at the contact points. The nicks are stress risers and fatigue type wire failures can result.

_Damaged wire breaks_ – Wire breaks or wire displacement from external wire rope damage or abuse are not considered a normal type of deterioration. The cause of this must be corrected. Scrubbing is a normal cause of damaged wire breaks and is described on page XX.

_Drum wear_ – All wire rope that spools on a drum is subjected to bending fatigue. Rope that spools in multiple layers on a drum experiences fatigue, scrubbing and crushing. These occur in proper “thread-laid” spooling where the rope on each layer primarily follows the valley between two adjacent wraps on the layer below. Where rope spooling is uncontrolled and not thread-laid, rapid deterioration of the rope will occur. Equipment with uncontrolled spooling must not be used until the spooling condition is corrected.

_Scrubbing_ – Scrubbing occurs when rope on a layer (other than the bottom layer) comes to the point where there is a previous wrap already in that valley between the two
ropes on the layer below. The rope coming onto the drum contacts the rope already on the drum and slides or “scrubs” against it. This contact forces the rope coming onto the drum to cross over to the next valley on the drum. This scrubbing contact occurs on the side of the rope and can cause damaged, displaced and/or broken wires but does not significantly affect the roundness of the wire rope.

**Crushing** – Crushing occurs at the same location in the length of the rope as scrubbing but occurs on the top and bottom of the rope. Because the rope goes from having two lines of contact when resting in the valley to a single point of contact during the cross over, the contact pressure is twice as high. This commonly leads to crushing of the rope at the cross over point. This will distort the roundness of the rope structure and damage individual wires. In addition to the damage, this inhibits the free movement of the wires and strand thus affecting fatigue life. The more layers of wire rope on a drum, the more likely that crushing will occur. In some severe operating conditions, crushing can occur where the rope rests in a valley.

![Image of wire rope](image)

**Change of layer point** – The change of layer point occurs at the end of a layer where the rope goes from one layer to the next higher layer. If there is no riser strip, the rope is ‘pinched’ between the preceding wrap and the drum flange to force it to the next layer. This pinching action can cause wire damage and distort the roundness of the rope.

**Corrosion** – Corrosion occurs progressively and can be slowed or stopped if action is taken before it progresses too far. Two stages of corrosion are described below. Proper rope selection and maintenance can reduce the likelihood of corrosion.

**Surface corrosion** – This is the beginning of corrosion and it can be wiped off the wires and the wire remains smooth and shiny. Once the rope is cleaned and the rust removed, application of a field lubricant to the rope will enable it to continue to be used.
Pitting corrosion – If the surface of the rope is cleaned and the wire is no longer smooth and shiny, pitting has occurred. Corrosion that has ‘pitted’ the surface of the wire requires retirement of the rope.

Red ‘rouge’ or red dust – When dry, red dust is present around the rope, check the particles with a magnet. When attracted to the magnet, there is internal fretting and/or corrosion in the rope. There is not an easy way to evaluate the severity of this condition and the rope must be retired.

Corrosion at End terminations – Corrosion at end terminations is especially critical because of the effect of corrosion on wire fatigue life. The damping of vibrations at this point is a normal fatigue location and corrosion accelerates this. If corrosion is localized at this point and there is sufficient rope length available, the affected area can be removed and a new end attachment made.

Rope distortion

Kink – A kink is a deformation created by a loop in the rope that has been tightened without allowing for rotation about its axis. This causes permanent, irreparable damage to the wire rope. The wire rope must either immediately be shortened to remove the area containing the kink or retired. Depending on the direction of the twist that caused the loop in the wire rope, a kink may either be a tightening (shorter wire rope lay) or a loosening (longer wire rope lay) kink.
Permanent Bends (dog legs) – Permanent bends in a rope are where the unloaded rope has a point where the rope changes direction. This is like a kink in that the wires at this point have been plastically deformed, but there is no change in the wire rope lay length at this point. This will be a point of more rapid wear and fatigue and is a reason for retirement if the deflection is greater than 30 degrees or it causes problems in the sheaves or spooling.

Waviness – Waviness is when the rope has a repeating pattern of undulation. Slight waviness often causes no operating problems. If the amplitude of the wave is greater than 1/3 the rope diameter, retire the rope.
**Lay length** – Lay length is the distance that it takes one strand to make a complete revolution around the wire rope. Wire ropes are designed with a specific lay length that enables all the wires and strands to share their proportion of the load.

**Rope stretch** – Rope stretch in normal loading conditions can be divided into ‘constructional’ stretch and ‘elastic’ stretch. Constructional stretch occurs during the initial loadings and use of the wire rope as the wires and strands adjust around the axis of the wire rope. This is normal, non-recoverable stretch that will result in a slight increase of lay length. Elastic stretch occurs during the normal loading of a wire rope as the steel stretches due to the applied load. When the load is removed, the wire rope returns to the pre-load length. Neither of these types of stretch cause a loss of wire rope strength under normal operating conditions.

**Rope rotation** – Wire rope rotation occurs when a wire rope is loaded and it is terminated in a swivel or a single part line that is lifting an unrestrained load. An axial load on a wire rope creates torque within the wire rope because the wires and strands are laid at an angle to the axis of the wire rope. Except in specially designed wire ropes, this load induced torque and the end of the rope free to rotate, cause the rope to rotate. This causes a change in the load sharing of individual wires and strands which results in a significant reduction in the wire rope’s breaking strength. Except for very low torque ropes (Category 1 rotation resistant ropes) every effort should be made to operate wire ropes in conditions where wire rope rotation cannot occur.

**Diameter reductions** – Measuring the diameter of a wire rope is one of the primary evaluation tools in wire rope inspection. To have meaningful comparisons, the measurement must be made at the areas where the greatest wear is expected or is being experienced. Each subsequent inspection must have the diameter measurements made at the same locations so that rate of diameter change can be observed.
**Seating of rope** – The ‘seating’ of a wire rope is the initial reduction in diameter that occurs when a wire rope is placed into service. At the time the constructional stretch is removed, the wire rope has a slight diameter reduction.

**Rope wear** – Rope wear, whether from abrasion or peening, reduces the diameter of the outer wire with a corresponding reduction in the wire rope diameter.

**Loss of core support** – Loss of core support allows the outer strands to pull-in closer to the rope’s axis, thus the wire rope diameter is reduced.

**Wire nicking** – Wire nicking of individual wires occurs at the strand-to-strand and strand-to-IWRC contact points. Over time, loading and bending around sheaves and drums causes these contact points to wear. Extreme loading, small diameter sheaves and sheaves with tight grooves will accelerate this wear. The wearing of these internal wire rope contact points will result in a reduction of the wire rope’s diameter.

**Loss of core support** – Loss of core support is typically identified when the diameter of the rope decreases significantly with no externally obvious reason for the change. The wire rope must be retired.

**Heat damage** - Heat damage from high temperatures can cause a variety of problems with different parts of a wire rope

**High temperatures**

**Fiber core** – Fiber cores (normally polypropylene) must not be use in conditions with temperatures higher than 180°F (82°C). Higher temperatures will cause core deterioration and loss of core support. Retire a fiber core rope if temperatures have exceeded this value.

**Lubricants** – Standard wire rope lubricants will melt at about 180°F (82°C). If a rope is subjected to temperatures higher that this, it needs to be inspected for corrosion and properly field lubricated before continued use.

**Steel** – Steel used in wire ropes is typically high carbon unalloyed steel that has significant cold-working to achieve the required strength. The properties (strength and fatigue resistance) of steel rope wire are affected at temperatures above 400°F (200°C). Wire ropes should not be used for applications where the temperature will exceed these values and must be retired if this limit is exceeded.
**Arcing** – Arcing occurs when an electrical current passes either to a wire rope or from a wire rope to another object. This creates a localized area of heating that changes the properties of the wire rope at that point. There is no positive way to measure or detect this in a rope in service. Any rope that is suspected of being subjected to arcing must be retired. Some typical causes of arcing are contact with electrical wires, lightning or using a wire rope to ground an electric arc welder.

**Extraordinary wear/damage** – this is wear, damage or distortion that occurs to the wire rope in a manner that is not typically encountered in a wire rope’s routine operation. This can occur due to mis-use, unforeseen occurrences or failure of other parts of the equipment. All inspectors must be on the alert for things that “don’t look right”. When found, the condition must be evaluated to determine if the wire rope can remain in service. It may be necessary to seek guidance of personnel with greater knowledge and experience in wire rope inspections for this evaluation. If in doubt, retire the wire rope.

**Wire Rope Removal Criteria** – The removal criteria for many applications is specified in regulations for the application and can include consideration for type of application, design factor used and consequences of failure. Special attention must be paid to the wire rope in and adjacent to idler sheaves and end terminations for fatigue wire breaks. Following are typical removal criteria for wire rope in general hoisting operations. If deterioration of multiple types is occurring, an aggregation of the conditions needs to be made to determine if rope retirement is necessary.

**Reduction in diameter** – reduction 5% or more from the wire rope’s nominal diameter

**Broken wires**
- In standard operating ropes, 3 crown wire breaks in one strand in one rope lay or 6 broken wires total in one rope lay.
- In rotation resistant operating wire ropes, 2 crown wire breaks in a length equal to 6 rope diameters or 4 crown wire breaks in 30 rope diameters.
- If a single valley wire break is found the rope must be retired.
- In standing ropes, more than one broken wire at or adjacent to an end connection.

**Corrosion** – evidence of pitting corrosion or red rouge dust. Pay special attention to end terminations.

**Heat Damage** - Any evidence that the rope has been subjected to heat damage or arcing.
**Change of Lay Length** – an increase in the rate of lay length change (comparison of measurements made during multiple inspections), a localized lengthening of lay (indication of loss of core support) or a large general lengthening of lay.

**Rope Distortion** – Evidence of severe scrubbing, crushing, waviness, or permanent bend.

**Kinks** – The area with the kink must be removed by shortening the wire rope or the wire rope retired.

Note: In some applications, if the condition necessitating removal is localized and near one end of the rope, the area exceeding the retirement criteria can be cut off and the remainder of the wire rope left in service.