Mining Rope Inspection

Inspection of mining ropes is difficult due to various factors, including lubrication applied during manufacturing and/or site contamination. Unlike other wire rope applications such as elevator and crane ropes, few guidelines and standards exist for inspection and removal criteria. ANSI M11.1 Section 5.9 offers inspection suggestions and gives examples of evidence of rope degradation (see Figure 1), yet offers no guidelines as to determining when wire rope should be retired. Therefore, it is left to the mine's discretion to establish inspection and retirement criteria and procedures. The following is meant to provide further direction in the inspection and retirement of mining hoist and drag ropes.

Wire rope inspection is vital in preventing a catastrophic failure, as well as determining and extending the safe operating limits of the rope. Regardless of the difficulty or inconvenience, never overlook inspection.

Hoist and drag ropes should be given a daily, cursory visual inspection for the purpose of discovering obvious damage to the wire rope, such as:

1. Rope distortion such as kinking, crushing, unstranding, birdcaging, main strand displacement, core protrusion, high stranding, looped wires or loss of rope diameter.
2. General corrosion, especially near end terminations.
3. Broken or cut strands.
4. Broken wires; number, distribution, type and time period in which they occur.
5. Evidence of heat damage from a torch or arcing from contact with an electrical conductor.

The frequency of detailed and thorough inspections must be determined by a qualified person who takes into account several variables, including:

1. Expected rope life as determined by maintenance records or experience with similar equipment and digging conditions.
2. Severity of digging conditions and any abuses that occur due to the digging conditions, such as pulling the rope through the overburden.
3. Blasting techniques and the structure of material moved.
4. Operator skill and exposure of the ropes to shockloading.
5. Weight and/or volume of material handled.

When performing a detailed inspection, use a spike or dry rag to remove lubrication and debris from the ropes. Never use a solvent to clean rope; the use of solvent will deplete the rope's lubricant and cause the rope to dry out.

5.9.3: Visual Inspection of Rope Degradation

In addition to the regularly scheduled inspection, the machine's operating personnel should report any visual evidence of rope degradation, such as:

1. Severe abrasion, scrubbing, peening, or kinking, or broken outer wires.
2. Crushing, or other damage that distorts the rope's structure.
3. Severe reduction of rope diameter or an observable increase in rope lay.
4. Birdcaging or other distortion indicating uneven distribution of load between rope strands.
5. Evidence of severe corrosion, particularly in the vicinity of attachments.
6. Uneven stretch of multiple ropes
7. Evidence of heat damage from a torch or arcing from contact with an electrical conductor.
8. A rapid increase in the number of broken wires.
9. A lack of lubrication.

Figure 1

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Figure 1: This dump rope shows severe abrasion.

Basic Inspection Guidelines

Abrasion

Abrasion damage may occur when the rope contacts an abrasive medium, or simply when it passes over the drum and sheaves. Therefore it is vital that all components be in proper working order and of the appropriate diameter for the rope. A badly corrugated sheave or drum will seriously damage a new rope, resulting in premature rope replacement. Refer to Bethlehem Wire Rope® Mining Technical Bulletin 2 on Sheaves and Drums for further information.

Corrosion

Corrosion is very difficult to evaluate. Usually signifying a lack of lubrication, corrosion will often occur internally before there is any visible external evidence on the rope's surface. A slight discoloration caused by rusting usually indicates a need for lubrication, which should be tended to immediately. If this condition persists, it will lead to severe corrosion, which promotes premature fatigue failures in the wires and strands, necessitating the rope's immediate removal from service. Pay close attention to areas adjacent to end terminations, which have the potential to trap moisture within the termination and subsequently the rope. If corrosion appears in these areas, remove the termination immediately for thorough inspection and possible rope cut-off.

Figure 3: Worn drag rope with multiple crown and valley breaks.

Wire Breaks

Rope retirement based on broken wires is determined by each mine, and varies depending upon the rope's application (hoist, drag or dump). When establishing the criteria for each piece of equipment, it is important to remember that each broken wire reduces the rated strength of the wire rope, as shown in Figure 2.

The number of broken wires on the outside of wire rope is an indication of its general condition and whether or not it must be considered for replacement. The inspector may use a cloth or type of spike to gently probe the strands for any wire breaks that do not protrude. Check the rope as it runs at a slow speed over the sheaves, where crown (surface) wire breaks may be easier to see. Also, examine the rope near the end connections. Keeping a detailed inspection record of the wire breaks and other types of damage will help the inspector determine the elapsed time between breaks. Note the area of the breaks and carefully inspect these areas in the future.

Valley breaks, or breaks in between strands, must be taken very seriously. Valley breaks

Figure 2: Reserve Strength for IWRC Ropes

Construction	No. Outer Wires	% Reserve Strength	% Rope Strength Lost Per Each Broken Wire	No. Broken Wires for 10% Loss of Strength*
6x26 Warrington Seale	10	46%	0.90%	11
6x25 Filler Wire 6x31 Warrington Seale	12	51%	0.68%	14
6x36 Warrington Seale 6x50 Seale Filler Wire Seale	14	57%	0.51%	19
6x49 Filler Wire Seale 6x57 Seale Filler Wire Seale	16	60%	0.41%	24
6x64 Seale Filler Wire Seale 6x70 Seale Filler Wire Seale	18	64%	0.33%	30

*Broken wires in one rope lay; little to no abrasive wear

are difficult to see. However, if you see one, there may be a few more hidden in the same area.

Crown breaks, as shown in Figure 3, are signs of normal deterioration, but valley breaks indicate an abnormal condition such as unusual deterioration or unusually heavy rope loading. In hoist applications, valley breaks require close observation. If several valley breaks are discovered in an isolated region, this area should be marked and watched. If, however, a series of valley breaks occurs over a long length of rope, such as 40 feet or so, an inspection should be made to determine the cause. At this time the mine should plan for a change-out, particularly if rope stretching or corkscrewing occurs. Drag ropes, on the other hand, suffer from an extreme amount of wire breakage due to the very nature of their application. It is for this reason that many mines choose to run drag ropes to destruction, or at the very least beyond recognition.

Figure 4: Damage from untrimmed broken wires was the cause of retirement in this rope.

Once crown and valley breaks appear, their number will steadily and quickly increase as time goes on. Remove broken wires, such as that shown in Figure 4, as soon as possible by bending the broken ends back and forth with a pair of pliers. In this way, the wire is more likely to break inside the rope where the ends will be tucked away. If the broken wires are not removed, they may cause further damage.

Diameter Reduction

Diameter reduction is a critical deterioration factor and can be caused by:

1. Excessive abrasion of the outside wires.
2. Loss of core diameter.
3. Internal or external corrosion damage.
4. Inner wire failure.

Reference Figure 5 for WW's recommended criteria for rope retirement due to reduction in diameter. It is important to check and record a new rope's actual diameter when under normal load conditions. During the life of the rope, periodically measure the actual diameter of the rope at the same location under equivalent loading conditions. This procedure, if followed carefully, reveals a common rope characteristic – after an initial reduction, the overall diameter will stabilize and slowly decrease in diameter during the course of the rope's life. This condition is normal. However, if diameter reduction is isolated to one area or happens quickly, the inspector must immediately determine (and correct, if necessary) the cause of the diameter loss, and possibly schedule the rope for replacement.

Original Diameter (inches)	Loss of Diameter
1-3/4" through 2-1/8"	1/8"
2-1/4" through 2-5/8"	5/32"
2-3/4" through 3-1/8	3/16"
3-1/4" through 3-5/8"	7/32"
3-3/4" through 4-1/8"	1/4"
4-1/2" through 4-5/8"	9/32"
4-3/4" through 5-1/8"	5/16"

Figure 5: Recommended Diameter Reduction Retirement Criteria for Mining Ropes

Other Rope Distortions

A cursory visual examination may detect other problems. By standing at one end and looking down the length of the rope, other serious rope distortions will be evident to a seasoned inspector. These types of distortions include waviness, corkscrewing, uneven stretching or sagging, and lengthening of rope lay. All of the conditions indicate a serious problem that is more than likely derived from core damage. If any of these conditions arise, the inspector must immediately determine the cause and appropriate course of action.

Specialty Wire Ropes

The inspection of plastic-infused and compacted-type wire rope poses new challenges in determining the safe operating limits of the rope. Inspection is now more difficult, but it can be accomplished. All of the inspection techniques and criteria still apply.

Plastic-infused Wire Rope

Plastic-infused wire rope was developed to provide better fatigue, abrasion and crushing resistance derived from the cushioning and dampening effect of the plastic. However great the benefits, the plastic becomes at the very least an inconvenience when trying to inspect the wire rope.

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i**Abrasion and Crushing.** In inspecting plastic-infused ropes, the basic inspection guidelines still apply and should be followed. Abrasion and crushing damage may still occur, so it is imperative to inspect flanges, sheaves, bearings, rollers and fairleads. Look for unusual wear patterns in the plastic – a key indicator that damage to the wire rope is occurring.

Wire Breaks. Wire breaks will still occur in a plastic-infused wire rope, but are sometimes extremely difficult to detect. Every effort must be made to determine the overall condition of the rope. The plastic covering the crown (surface) wires is relatively thin and tends to wear quickly in areas that pass over sheaves and drums. As the rope runs at a slow speed, inspect the rope in these areas. If a wire break is detected, closely watch the rope and increase the frequency of inspection; due to the nature of plastic-infused ropes, there is no way to clearly determine the number of wire breaks. Also inspect areas where the plastic has peeled, regardless of the location of the "window". Remove as much plastic from these areas as possible to allow for efficient and effective inspection techniques.

Corrosion. Plastic-infused ropes provide only improved corrosion resistance. Regardless of manufacturers' claims, a plastic-infused wire rope can corrode, and rope failure due to corrosion is still possible. Moisture may become trapped within the rope, and over time, the manufacturing lubricant may become ineffective. The inspector must visually check for any signs of corrosion damage as evidenced by rope bleeding or rouging. In addition, the diameter must be frequently measured. If there is any damage to the core, it will be detected by a reduction in diameter. Also inspect the lay of the rope. As the plastic is thinner over the crown wires, a thorough inspector may be able to determine a lengthening of lay, also a sign of rope deterioration. Especially when trying to determine lengthening of lay, watch for and inspect areas where the plastic pulls away from the rope. While peeling, in and of itself, is not an indication of rope deterioration and is a factor of normal wear, peeling in areas where no abrasion exists may signify a rope problem.

Maintenance Records. Equally important in inspecting plastic-infused ropes is maintaining accurate service records. The service records of previous ropes will provide a guideline as to the expected life of the rope. However, they should not be used alone or only in conjunction with visual inspections due to the number of variables that exist, including installation and manufacturing practices. Maintenance records must be used in combination with visual and physical inspection techniques and consideration of operating variables to be truly of value in determining the remaining life of the rope.

Compacted Wire Rope

In the inspection of ropes with compacted strands, it is imperative to follow the basic inspection guidelines, using both visual and actual measuring techniques to determine the remaining life of the rope. In fact, actual measuring techniques are very important when inspecting these ropes. While corrosion is relatively easy to visually determine, diameter reduction may not be due to the compacted rope's appearance. Therefore, the inspector must record the new rope's actual diameter immediately after installation to determine the baseline for future evaluation, followed by regular measurements for diameter reduction and close examination of the rope for lay lengthening. Measurements must be recorded and the rope monitored for sudden variations.

Generally, the most difficult removal criterion to evaluate in compacted ropes is wire breaks, which may not protrude from the rope due to the compaction and are easily overlooked. Because of this, the inspector must slowly and carefully examine the rope, especially in those areas passing over drums and sheaves or in areas where problems existed in previous ropes.

If the inspector notes a flaw in a wire, it should be carefully checked. If a break has occurred, thoroughly check the area for additional breaks, both on the crown and in the valleys. Remember, valley breaks in round strand ropes are difficult to determine; compaction only increases the difficulty. The inspector must be slow and methodical in inspecting compacted ropes; a quick check will reveal nothing.

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