EVALUATION OF LUIBRICANTS TO INCREASE WIRE ROPE LIFE

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ABSTRACT

The Bureau of Mines, U.S. Department of the Interior, determined that the life of hoist ropes can be increased by regular application of selected lubricants to decrease internal corrosion and wear, thus reducing rope replacement expenses. Lubricant effectiveness is determined by nondestructive testing (NDT) at intervals throughout the rope life. A rope is passed through a sensor head that detemines the loss of metallic area (LMA) and the local faults (LF) such as broken or misraing wires. The LMA and LF are presented as traces on a strip chart. The nondestructive testing method provides advantages over a visual rope inspection because it allows detemination of the structural integrity of the internal rope parts and requires less interruption of the hoisting for testing. This report discusses the observable trends in the LMA and LF traces, which indicate that thin, penetrating synthetic lubricants extend rope life.

INTRODUCTION

Wire ropes used in mine hoisting operations often have greatly shortened service lives because of excessive internal corrosion and wear. However, the service lives can be increased by regular field applications of lubricants to reduce the corrosion and wear.

The traditional method of evaluating lubricant effectiveness has been to Perform reveral laboratory tests 3 to compare desirable lubricant properties such as corrosion resistance, viscosity and adhesion. Wire rope consists of a core, strands, and wires (figure 1). As a rope is loaded during hoisting operation, the strands and wires rub against each other and against the core, which makes the rope behave as a machine with several moving parts. The laboratory test often do not evaluate a rope under load. Consequently, they are not able to deteriane the extension of rope life with proper lubricant usage.

A better, method of evaluating lubricant effectiveness is to test a rope by the NDT procedure at periodic intervals throughout its service life. The rope is passed through a sensor head that determines the rope's loss of metallic area (LMA) and local faults (LF) such as broken or missing wires. The NDT method, while not eliminating the visual rope inspection, provides advantages in that it allows determination of the structural integrity of the internal rope parts and requires less downtime for testing. Researchers at the Bureau of Mines Spokane Research Center evaluated NDT data on various ropes by comparing the LMA and LF and noting the trends.

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DESCRIPTION OF A HOIST ROPE SYSTEM

One arrangement of hoist ropes in a molybdenum mine consists of five ropes: (1) the service cage rope, (2) the service cage counterweight rope, (3) the small cage rope, (4) the south waste hoist rope, and (5) the north waste hoist rope. All of these ropes were subjected to similar environmental conditions. A side view of the rope arrangement is shown in figure 2; a plan view is shown in fig 3.

The south and north waste hoist ropes were evaluated for the effects of lubricants on rope life. These ropes are 6 X 27 FS FC RLL, 1-3/8 inches in diameter and 1,150 feet long. The ropes are exposed to 0 to 90 degrees Fahrenheit in an acidic environment having over 50% relative humidity. They are raised and lowered with an 8 foot diameter double-drum hoist. Both ropes pass over 8 foot diameter sheaves. The average rope load is 10 tons at a rope speed of 850 feet/minute.

South Waste Hoist

Figure 4 shows the LMA portions of the strip charts for the south waste hoist. The first LMA trace (separated from the others) is for a rope retired from service after 19 months; the other LMA traces are for the replacement rope. Two rope determinations are indicated. The second rope determination cut off the maximum LMA of the rope that was read from the strip charts, requiring that the LMA be read at a second chart location.

As figure 4 shows, the LMA increased as the replacement rope aged but at a much slower rate than for the retired rope. The lubricants are shown in figure 4 along with the rope age and the LMA.

Figure 5 illustrates how the LMA is read from the strip charts. The uppermost portions of the LMA trace normally represent those sections of the rope with the least metal loss. The horizontal dotted line (0% LMA line) assumes that there is no metal loss from the best rope sections (which is not always the case). The NDT instrument is calibrated so that each of the 10 major vertical divisions on the strip chart represents a 1% LMA. The maximm LMA of 9.9% is obtained by counting the major vertical divisions between the 0% LMA Line and the lowest point on the LMA trace.

The asphalt-bars, nonpenetrating lubricant performed poorly as evidenced by the rope retirement after only 19 months of service. The replacement rope had rice-oil-base, pentrating lubricant applied after 6 months of service and a synthetic penetrating lubricant applied thereafter. The extension of rope life is indicated by thd much smaller LMA after 34 months than for the first rope after 19 months.

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3 Critical Assessment of the State of the Art of Lubrication for Mine-Hoist Ropes, final report, Contract J0377011, Battelle Columbus Laboratories, Columbus, Ohio, July 1978.

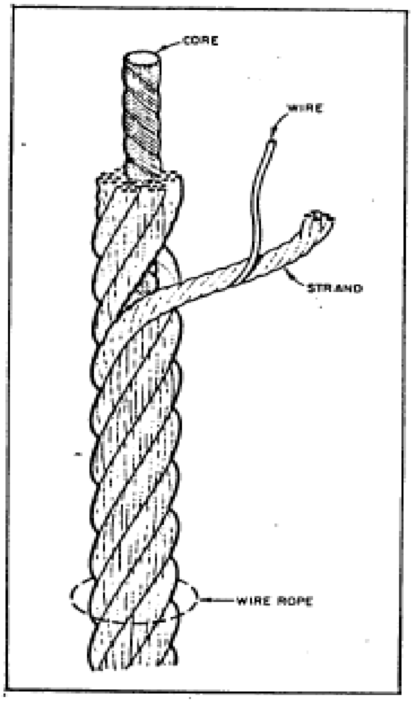


Figure 1 *- Three parts of a wire rope.*

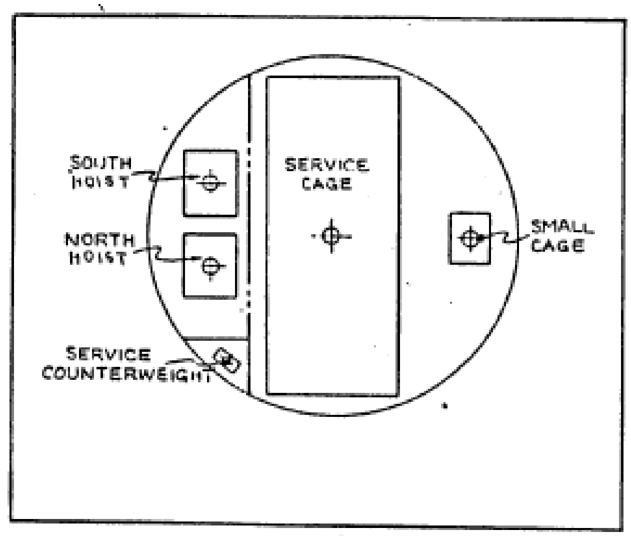


Figure 3 *- Plan view of hoist ropes*

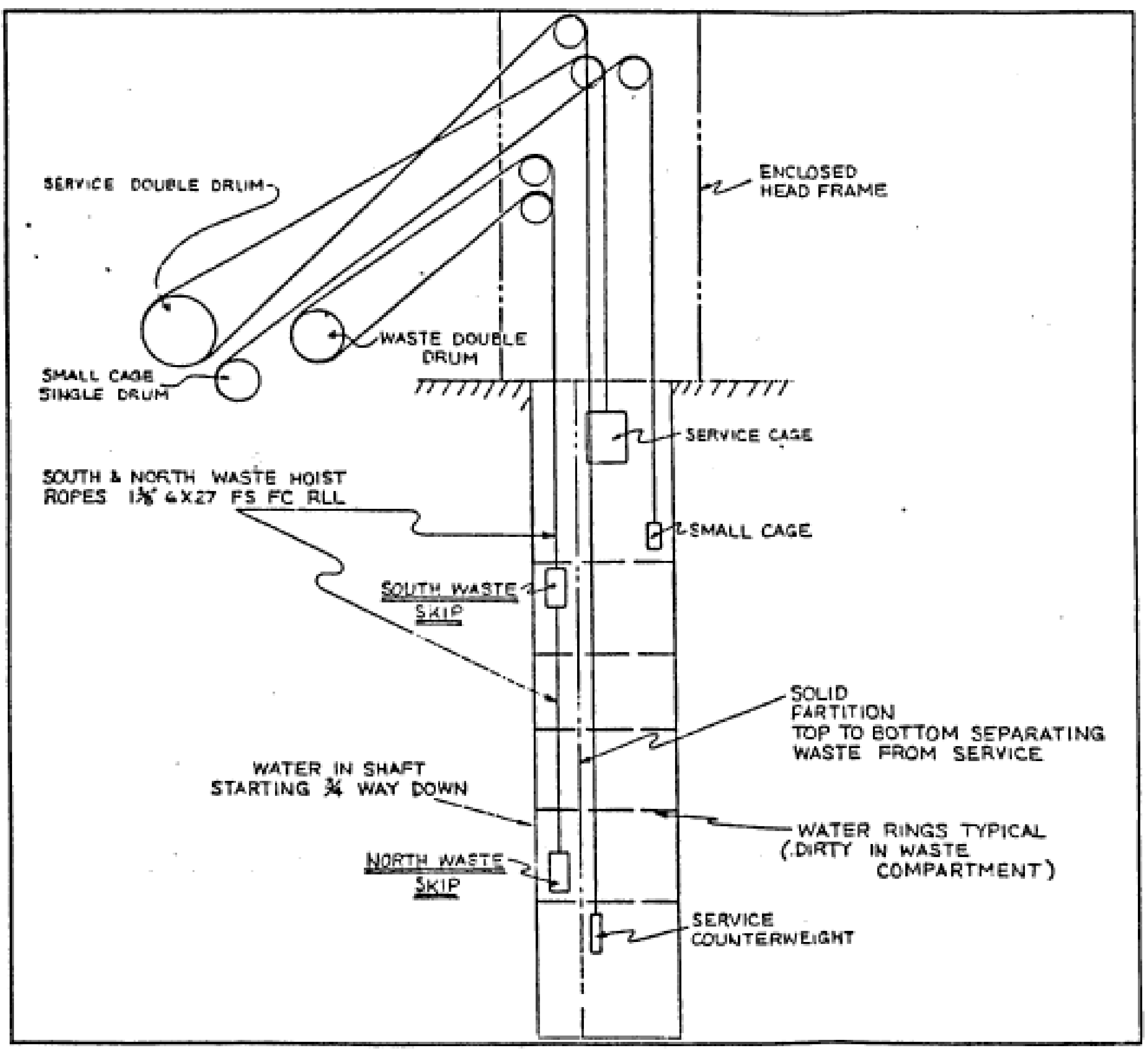


Figure 2 *- Hoist rope arrangement*

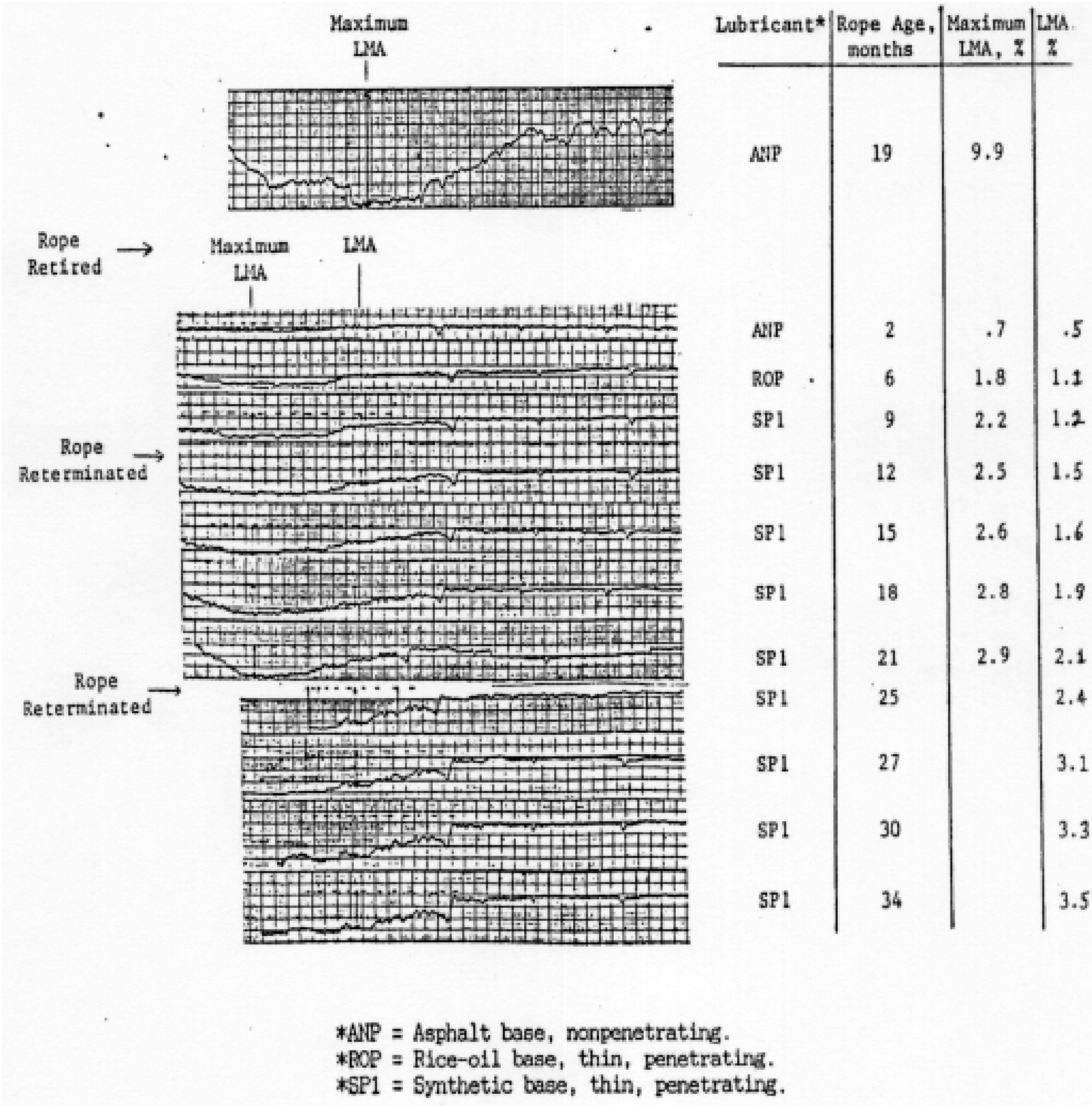


Figure 4 *- LMA strip charts for mine 1 south waste hoist ropes.*

Figure 6 shows a plot of the LMA versus rope age. The lubricants and rope reterminations are also indicated. Those LMA's shown as black squares (■) are the maximum LMA's on the rope before the area was cut off. Those LMA's shown as black circles ( ) are a● the same point on the rope past the reterminated section. The retermination before the 25 month test placed the remaining rope closer to the skip; this increased the rate of LMA because the skip descends into an environment that promotes greater internal corrosion.

Figure 7 shows the LF portion of the strip charts for the south waste ropes. The charts show that, due to more internal corrosion, the vertical widths of the traces are greater in those areas where the LMA's are larger. Also shown is the rope age and "LF factor." The LF factor is the percentage of total strip chart squares that contain at least one LF trace. As the rope ages, the LF factor will increase as the rope degrades. A smaller LF factor with increasing rope age as shown at 25 months (figure 7) is the result of slight variations in instrument calibration.

Figure 8 shows a plot of the LF factor versus age. The first rope had a larger LF factor due to its greater internal corrosion. As the replacement rope aged, its LF factor increased.

North Waste Hoist

Figure 9 shows the UIA traces for the north waste hoist ropes. The information is similar to that for the south waste ropes because both hoists are side by side and had similar lubricants applied. The first rope, again, showed a greater LMA after 19 months than did the replacement rope after 34 months. The asphalt-base, nonpenetrating lubricant on the first rope did not reduc6 internal corrosion.

Figure 10 shows the LMA for the north waste hoist rope versus the rope age. As the rope aged, the LMA increased; however, the synthetic-base, thin, penetrating lubricant slowed the growth of internal corrosion more than did the asphalt-base lubricant.

Figure 11 shows the LF strip charts for the north waste hoist ropes. As before, the vertical height of the LF trace is greater in those areas that have more internal corrosion. The smaller LF factor with increasing rope age is caused by variations in instrument calibration. Figure 12 shows the larger LF factor for the first rope and the LF factor growth as the replacement rope ages.

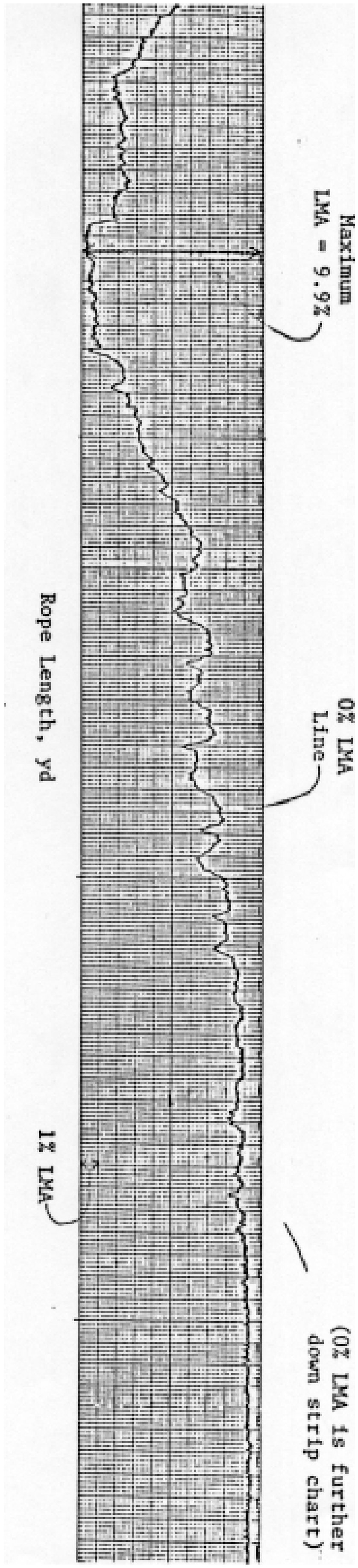


Figure 5 *- How the LMA is read from the strip chart.*

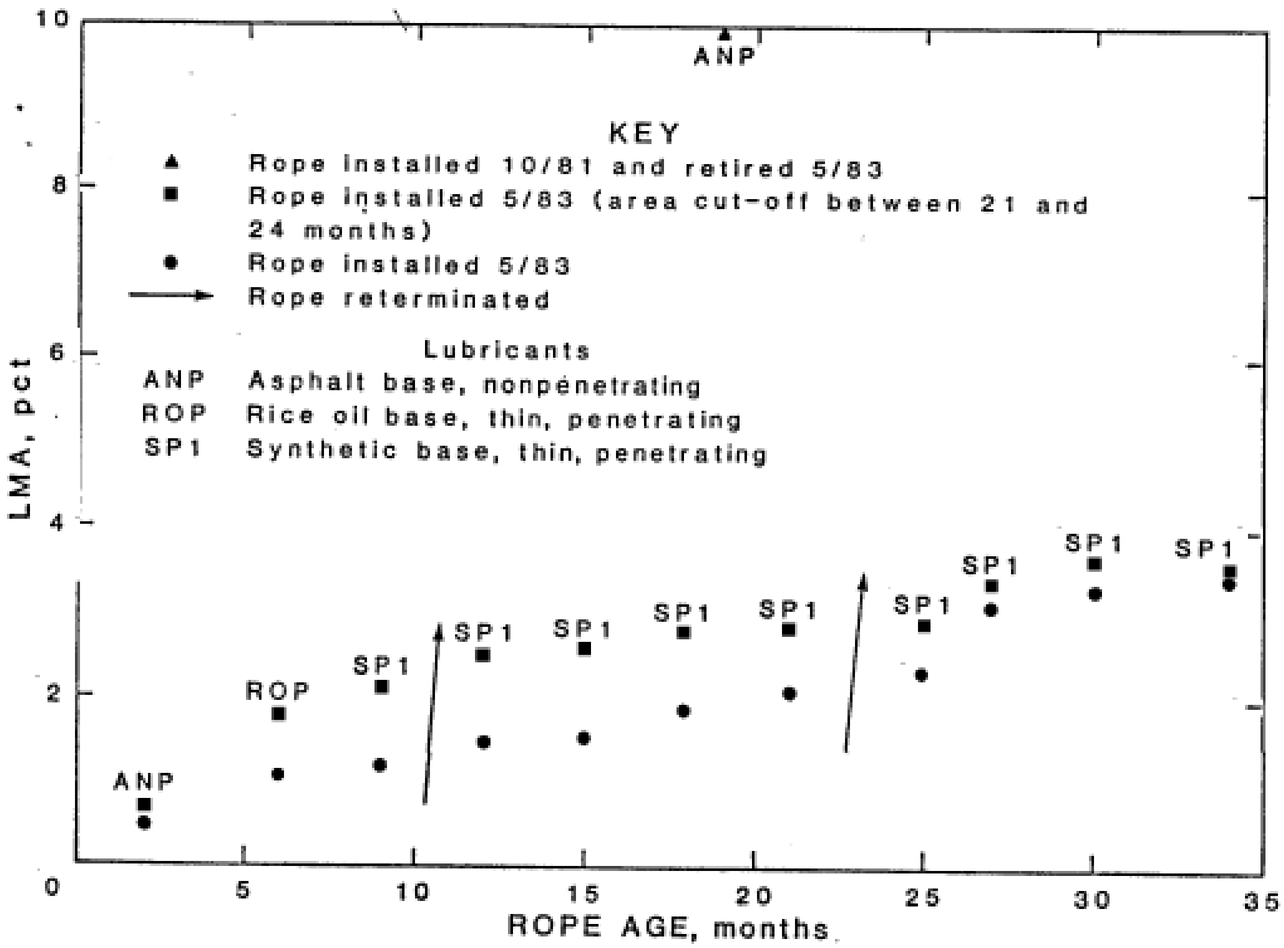


Figure 6 *- LMA for mine 1 south waste hoist ropes.*

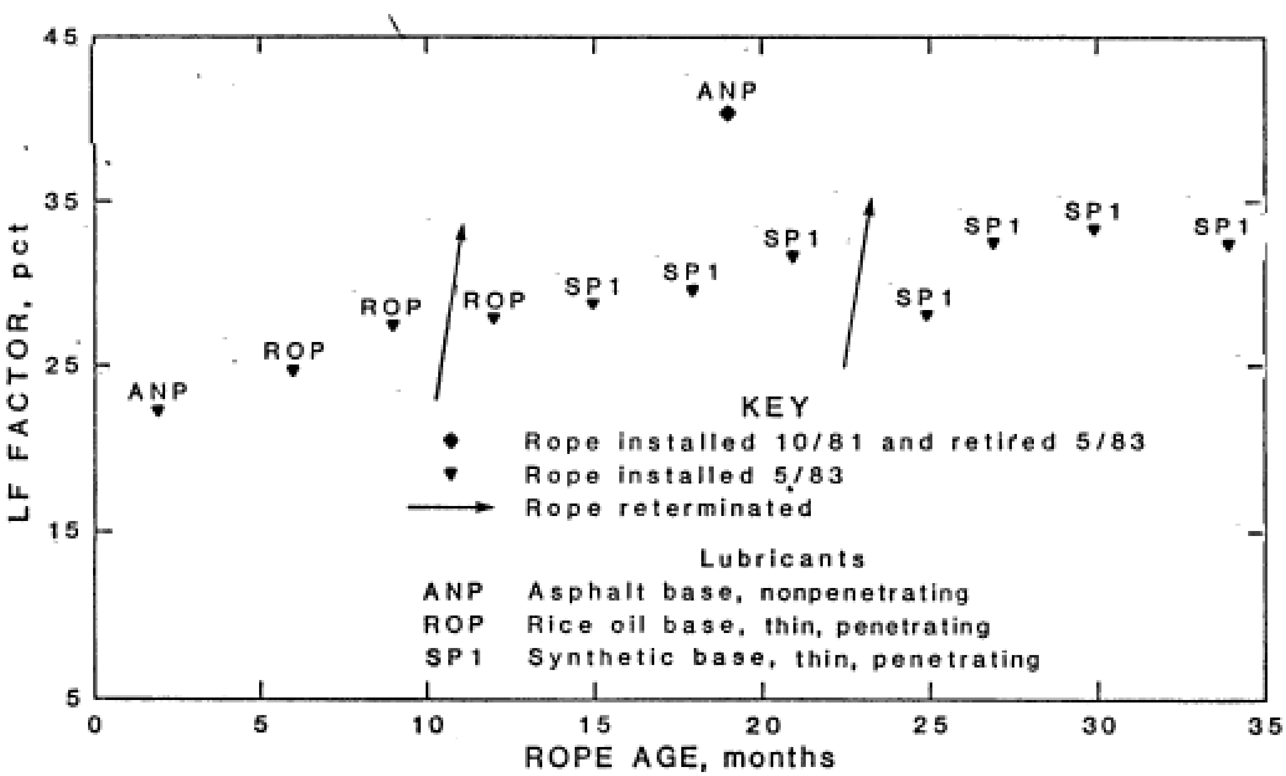
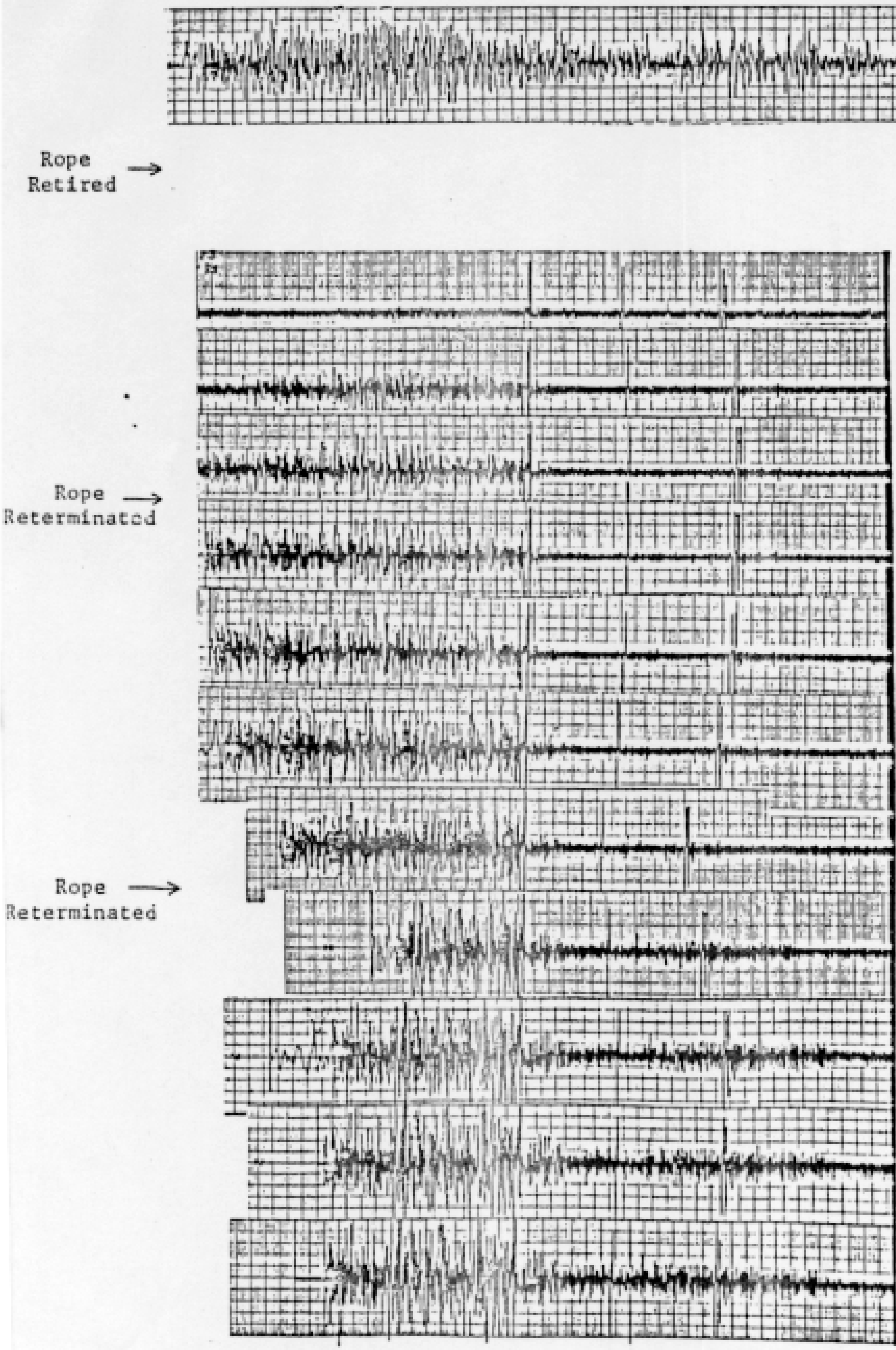


Figure 8 - *LF factors for mine 1 south waste hoist ropes.*



Lubricant*	Rope Age, months	LF** Factor
ANP	19	40.3
ANP	2	22.3
ROP	6	24.8
SP1	9	27.5
SP1	12	28.0
SP1	15	28.9
SP1	18	30.7
SP1	21	31.7
SP1	25	28.1
SP1	27	32.6
SP1	30	33.3
SP1	34	32.4

*ANP = Asphalt base, nonpenetrating.
*ROP = Rice-oil base, thin, penetrating.
*SP1 = Synthetic base, thin, penetrating.
**LF factor = % of strip-chart squres containing a local fault trace.

Figure 7 *- LF strip charts for mine 1 souyh waste hoist ropes.*

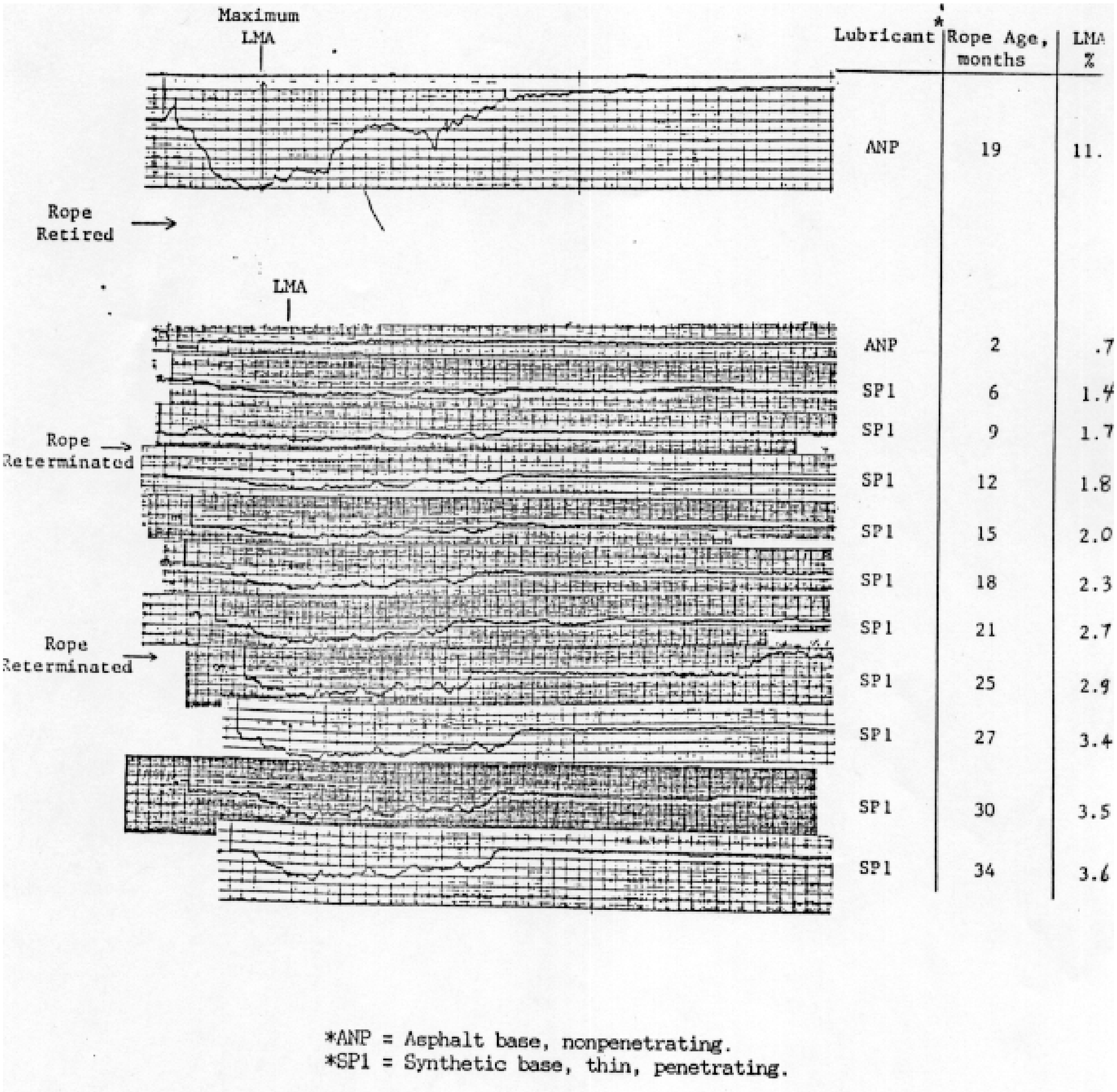


Figure 9 *- LMA strip charts for mine 1 north waste hoist ropes.*

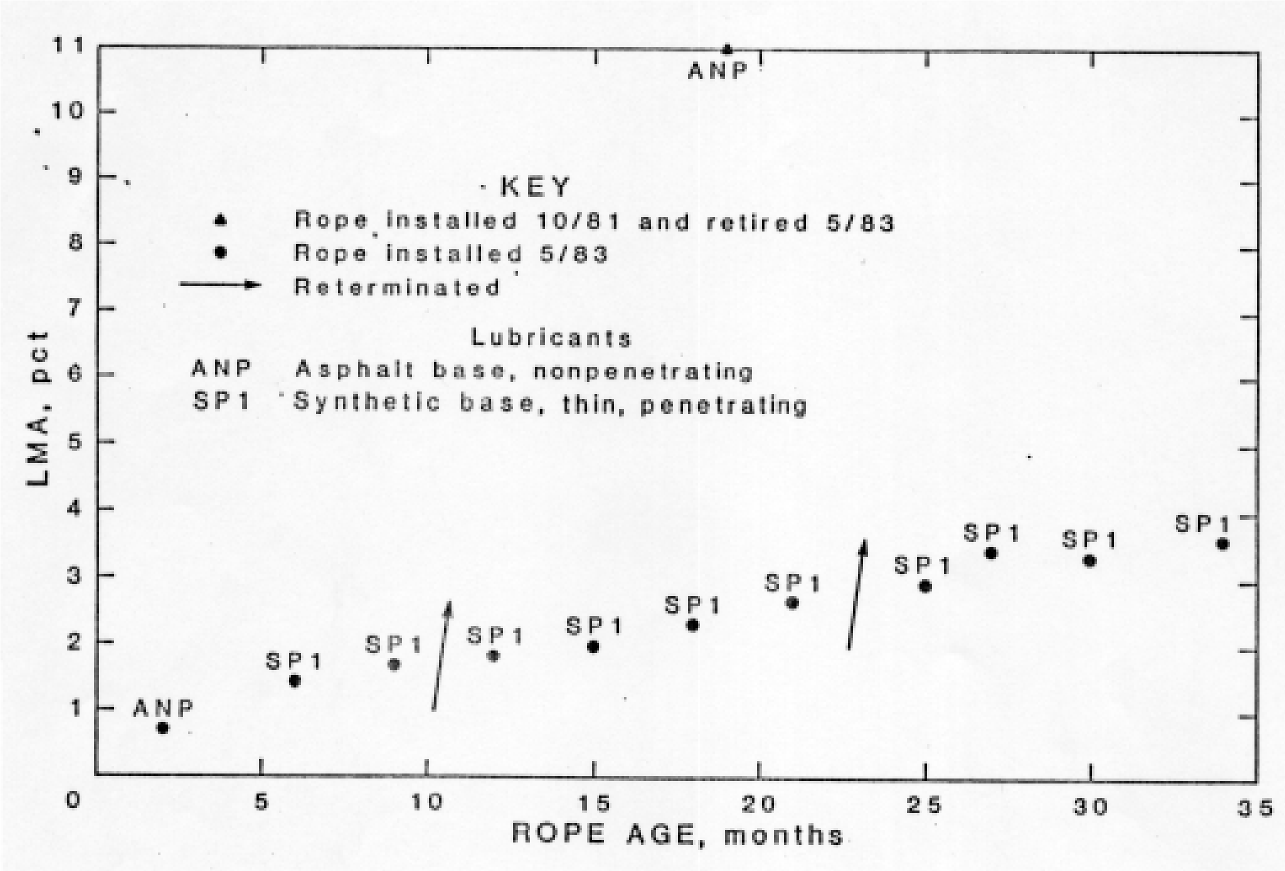


Figure 10 *- LMA for mine 1 north waste hoist ropes.*

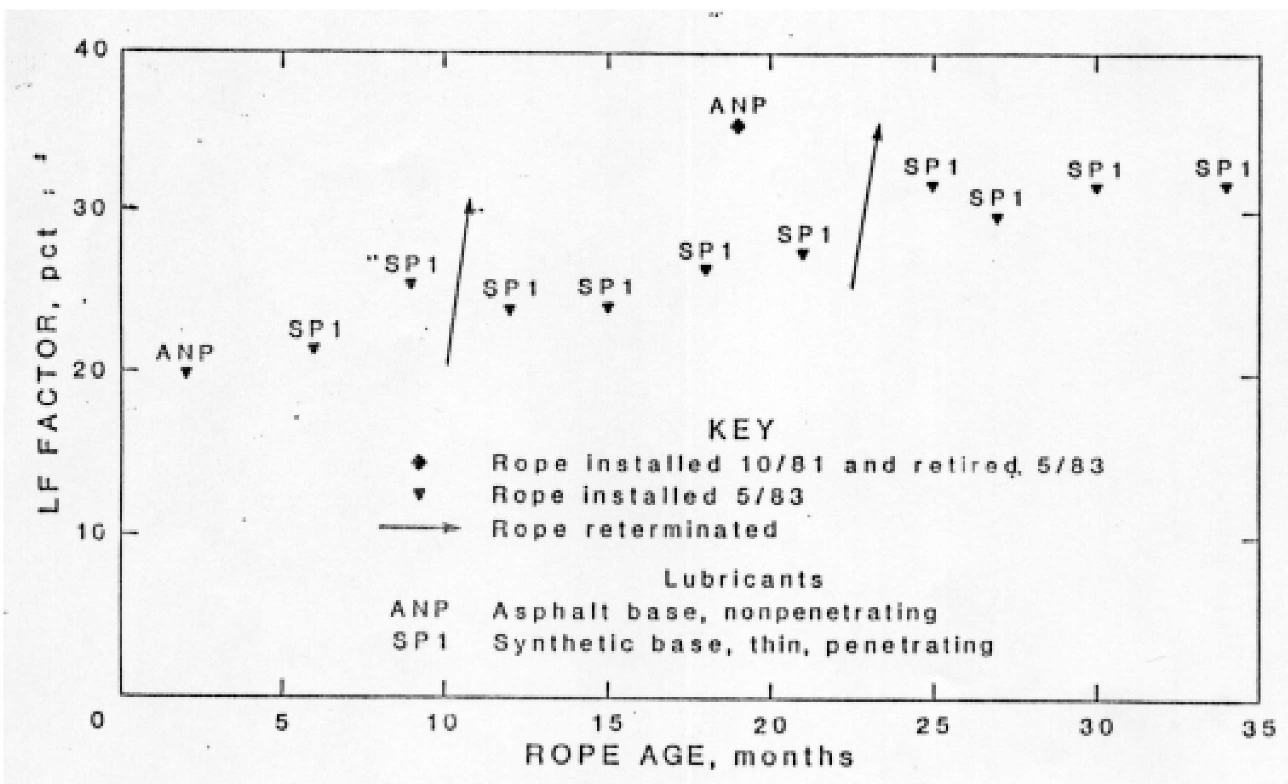


Figure 12 *- LF factors for mine 1 north waste hoist ropes.*

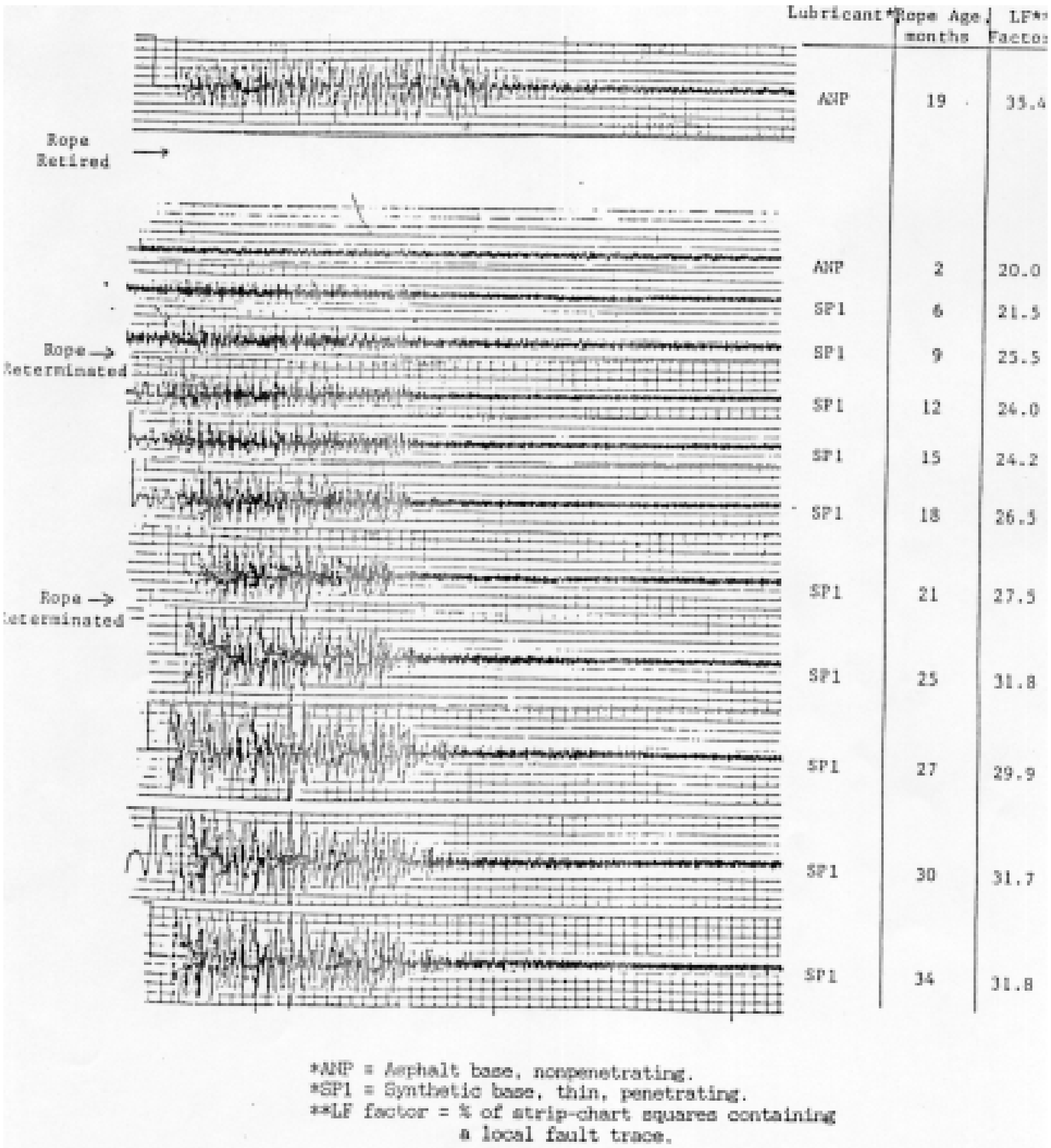


***Figure 11** - LF strip charts for mine 1 north waste hoist ropes.*

SUMMARY

As a rope is loaded during hoisting operation, the strands are tensioned and pushed toward the core, causing the rope length to increase and the rope diameter to decrease. The wires rub against one another, causing wear. Ropes are simultaneously subjected to environmental conditions, such as high humidity and acidic mine water, which cause rapid internal corrosion. The internal corrosion and wear reduce the metal area on the rope with consequent loss of strength.

As illustrated by the analysis of the strip charts, the thin, synthetic lubricants capable of penetrating the spaces between the wires and into the core are able to extend rope life significantly where internal corrosion and wear are present. By coating the wire surfaces with lubricant, both corrosion and wear can be reduced. The rope does not require an excess of lubricant at one time, but a small amount applied periodically.

The strip charts also show that the heavy, nonpenetrating lubricants can cause rapid internal corrosion and deterioration. In some cases, they may even accelerate internal corrosion by promoting the retention of moisture inside the rope.